SPACE ORDNANCE SYSTEMS

TP 8877

FINAL TEST REPORT

FEASIBILITY DEMONSTRATION

OF

BOOSTER CROSS-OVER SYSTEM

FOR 3½ INCH SRB/MLP FRANGIBLE NUT

FOR

NASA

MARSHALL SPACE FLIGHT CENTER

SOS Sales Order No. 1348 Customer Contract No. NAS8-34651

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Test Manager _____

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SOS-19113

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1.0 INTRODUCTION

Recent testing of the SRB/MLP Frangible Nut System (SOS Part Number 114850-9/Boosters P/N 114848-3) at NASA indicated a need to reduce the function time between boosters (2) within a single frangible nut. These boosters are initiated separately by electrical impulse(s). Coupling the ouput of each detonator with an explosive cross-over would reduce the function time between boosters (independent of electrical impulse) while providing additional redundancy to the system. SOS was awarded a contract (NAS8-34651) to conduct a "feasibility demonstration program".

1.1 Program Objectives

The objectives of this program were to:

A) Provide an explosive cross-over between boosters.

B) Reduce function time between boosters to less than one (1) millisecond within a given nut.

C) Reduce cost of boosters.

D) Be compatible with the existing frangible nut system.

E) Meet requirements of USBI Spec's (nut 10SPC-0030, booster 10SPC-0031).

2.0 DESIGN

The finalized design for the improved 3½" frangible nut is shown on SOS drawing 117245 and is presented as Figure 1.

The design consists of five (5) major components:

A) Nut (modified) P/N 11784-1 as Figure 2

B) Booster Assembly P/N 117240-1 as Figure 3

C) Cross-over Assembly P/N 117239 as Figure 4

D) Adapter P/N 117238-1 as Figure 5

E) Detonator (CFE) SEB 26100094-201

As can be seem from Figure 1, the design provides an envelope that is within the existing design envelope, therefore compatible with debris container/connector installation.

2.1 Nut P/N 117184-1

The proposed design incorporates the requirements of the existing design Frangible Nut SOS P/N 114841-5. The nuts used in the verification test were nuts from a previous accepted lot and modified for this program. This demonstrates not only system compatibility, but existing nuts can be modified/reworked to the proposed design.

2.1 Nut P/N 117184-1 (continued...)

The proposed design maintains characteristics that control the existing nut design structural capabilities.

Modifications/rework consists of mounting provisions for the cross-over assembly and the adapter.

2.2 Booster Assembly P/N 117240-1

The proposed booster is made from mild detonating fuse (MDF) having an aluminum sheath and RDX core. The length of MDF used in the assembly is taken from a length of MDF that has previously been tested for core load (explosive content) and detonation velocity. The end closures are aluminum and laser welded. The existing booster has a stainless steel body with the RDX core being loaded in increments. The end closures are stainless steel and resistance welded. Both designs are capable of passing a dry leak helium test (1×10^{-6} cc/sec).

Listed below is a comparison of major characteristics of the two designs:

2.2 Booster Assembly P/N 117240-1 (continued...)

CHARACTERISTIC	EXISTING DESIGN	PROPOSED DESIGN
RDX per MIL-R-398	7.25 grams	7.87 grams
Output O.D. inch	.480/.484	.480/.484
Output I.D. inch	.354/.356	.354/.356
Output length inches	2.78 inches	2.81 inches
Housing material	Stainless Steel	Aluminum
Closures	Stainless Steel	Aluminum
Welding (closures)	Resistance	Laser
Dry leak capability	1×10^{-6} cc/sec.	1×10^{-6} cc/sec.
Output plate dent in steel 0.078 inch minimum deep	Lot AAF	Lot 1
Actual	(26) $\bar{x}$ .126 .113 min/.146 max.	(15) $\bar{x}$ .132 .128 min/.136 max.

2.3 Cross-over Assembly P/N 117239-1

The cross-over assembly consists of a length of MDF (having a core load of 10 ± 1 gr./ft.), an adapter (Figure 4a) epoxied to the MDF at each end (MDF trimmed after expoxy cure), a booster cup loaded with 46 mg. of RDX, resistance welded to the adapter. This sub-assembly is housed in a stainless steel tube, welded to a retainer (Figure 4b) at each end, end booster location controlled and potted to the retainers (Figure 4). The cross-over

2.3 Cross-over Assembly P/N 117239-1 (continued...)

is then formed into the configuration shown. The interface between the MDF and loaded cup is the same as SOS currently utilizes on other programs and has been well proven.

The relationship between CFE detonator and the cross-over booster is consistant with other "flying plate initiation" designs and can be easily controlled.

The design of the cross-over retainer (Figure 4b) provides a "symmetry" of MDF booster to retainer mounting faces, therefore eliminating the need for specific cross-over assembly installation/orientation.

The retainers (Figure 4b) have a recess on each side. One recess locates over the booster shoulder, the other indexes on the adapter (Figure 5) therefore insuring concentricity of all components/sub-assemblies.

2.4 Adapter P/N 117238

The adapter provides a means for retaining the installed booster (Figure 3) in place. The adapter has an internal threaded port which mates with the CFE detonator and locates the

2.4 Adapter P/N 117238 (continued...)

detonator such that the gap relationships between the detonator and booster (Figure 3) and detonator and cross-over booster (Figure 4) are controlled.

2.5 Detonator P/N SEB 26100094-201 (CFE)

The detonator is the same configuration as has been used on all frangible nut and booster testing.

2.6 Related Test Components

Components used in the test/evaluation of this design although not identical to component configuration represent the parameters being evaluated. These components include cross-over test assemblies, simulated port fixture etc., and are included in Appendix A.

3.0 TESTING

A test program outline SOS document TP8867 was prepared, submitted to and concurred with by Joe Davis (NASA, COR). The testing reported herein was in support of that outline. Test summary is shown as Table I and the testing basically consisted of evaluating seven (7) key elements of the design:

A) Detonator/cross-over - detonator as donor

B) Detonator/cross-over - cross-over as donor

C) Detonator/cross-over - cross-over @ 85% load

D) Detonator/cross-over/booster - interface compatibility

E) Detonator to booster

F) Booster performance

G) System verification

The following sub-paragraphs address these key elements in detail.

3.1 General

All testing was conducted at SOS Placerita Facility. Instrumentation used to obtain data was in accordance with SOS quality requirements (calibration, etc.).

Testing was conducted at ambient conditions.

3.1.1 Detonators SEB 26100094-201

All detonators fired during this program were CFE by NASA. Except for tests 7 - 12, which were cross-over initiated (use of a blasting cap), the detonators were electrically initiated by application of 3.5 amps/10 millisecond pulse to the detonator bridgewire.

Although specific tests were designed to evaluate certain component relationships, these pertinent data were measured and recorded for all tests where applicable.

3.2 Detonator/Cross-over - Detonator As Donor

Six (6) tests were conducted evaluating this relationship. Three (3) tests incorporated component gaps of nominal, .050 inch and three (3) tests at 50% over nominal or .075 inch.

All test units functioned successfully. The test set-up was as shown in Figure 7 and consist of tests 1 through 6.

3.3 Detonator/Cross-over - Cross-over As Donor

Six (6) tests were conducted evaluating this relationship.

3.3 Detonator/Cross-over - Cross-over As Donor (continued...)

Three (3) tests incorporated component gaps of nominal, .050 inch and three (3) tests at 50% over nominal or .075 inch.

All test units functioned successfully. The test set-up was as shown in Figure 7 and consist of tests 7 through 12.

3.4 Detonator/Cross-over - Cross-over At 85% Load

Five (5) tests were conducted evaluating this relationship. Component gaps were measured and recorded (see Figure 8).

All test units functioned successfully. The test set-up was as shown in Figure 8 and consists of tests 13 through 17.

This test series incorporated function time measurements and this data is included in Table II test results.

3.5 Full-up Propogation - Dual Detonators/Boosters

Three (3) tests were conducted evaluating the combined ordnance interfaces. Component gaps were measured and recorded (see Figure 9). The test set-up was as shown in Figure 9 and consists of tests 18, 19, and 20.

This test series incorporated function time measurements and this data is included in table II test results. In addition, booster output "plate dent" data was obtained to be used in evaluating booster performance acceptance criteria. This plate dent data is included in Table III test results.

3.6 Detonator to Booster

Three (3) tests were conducted evaluating this relationship. Two (2) tests incorporated a "minimum" design gap of 0.027 inch and one (1) test incorporated a maximum design gap of 0.063 inch.

All test units functioned successfully and all plate dent depths were in excess of the 0.078 inch depth minimum. The set-up was as shown in Figure 10 and the dent depth data is recorded in Table III.

3.7 Booster Performance

This series of tests was designed to evaluate booster performance that may be affected by the core load (quantity of explosive - RDX) contained in the booster. As described in Paragraph 2.2, the booster is made from MDF. The amount of explosive within the MDF-(core) is determined by a core load determination taken by a random sample through a given length of MDF. These (6) tests, three (3) at minimum and three (3) at maximum core load were selected based on these core load determinations.

All units functioned successfully. The test set-up was as shown in Figure 11 and consists of tests 24 through 29. The plate dent data is tabulated in Table III.

3.8 Booster Acceptance Criteria

The results of fifteen (15) tests were evaluated in an effort to:

A) compare results to specification requirements, and

B) establish acceptance performance criteria.

These test results are tabulated in Table III, performance data from tests 18 through 29. As noted in Table III results,

3.8 Booster Acceptance Criteria (continued...)

the recorded plate dents are well in excess of the required 0.078 inch minimum and exhibit a "closer" spread "minimum to maximum" than the most recent DLAT lot of boosters (SOS P/N 114848-3 lot AAF).

3.9 Verification

Three (3) tests were conducted to verify that the proposed cross-over and MDF booster were compatible with the existing frangible nut system.

The tests numbered 45, 46, and 47 functioned successfully therefore, demonstrating system compatability.

The major endeavor of this program, as previously discussed, was to "verify cross-over function time of less than one (1) milisecond". The function time data from these three (3) tests as well as from tests 13 through 20 are recorded in Table II. As noted, maximum function time between boosters from all tests was "260 microseconds" well within the desired one (1) millisecond.

3.9.1 Test Set-up

The system that was tested utilized a frangible nut assembly SOS drawing 117245 (Figure 1). This assembly consisted of a modified frangible nut SOS drawing 117184 (Figure 2), cross-over assembly SOS drawing 117239 (Figure 4), boosters (2) SOS drawing 117240 (Figure 3) and adapter SOS drawing 117238 (Figure 5).

The instrumentation set-up was as shown in Figure 12.

For the three (3) tests, the nuts were not assembled to a test stud, therefore, no tensile load was applied during functioning.

3.10 Data

3.10.1 Gaps, Component Interface

As components were arranged into their specific test set-up, measurements were taken, gaps determined and recorded on applicable data sheets. Where required by test criteria (specific gaps) components were modified at assembly or shims added to provide their specific gaps.

3.10.2 Detonators P/N SEB 26100094-201

The forty-three (43) detonators used on this program were CFE by NASA. Serial numbers of these detonators were recorded on the data sheets for the applicable test. Where required function time, application of current to bridgewire burn-out, is recorded.

3.10.3 Function Time Analysis/Interpretations

As previously noted, the instrumentation set-up for measuring specific funtion time is shown schematically in Figure 12.

The scope used was a Nicolet digital scope model 2090. A firing pulse generator provided necessary current for functioning the detonators. Upon application of this current the scope triggered providing the "bridgewire" burn-out data. The "break link" box consisted of six (6) circuits and any combination of these circuits could be utilized. The "break links" were lengths of insulated wire strategically located as shown in Figure 12. These break links had a "low voltage" across them and when broken, due to an ordnance event, would cause a voltage shift and show up as a position change on the horizontal sweep of the scope picture. Therefore, each break link had a unique position on the scope and its position

3.10.3 Function Time Analysis/Interpretations (continued...)

was previously determined during the calibration process.

The Nicolet sweep speed was set at four (4) milliseconds across the full face.

Upon completion of the event and to determine exact function times, portions of the event would be expanded, utilizing the scope electronics, and very accurate time measurements could be made.

Appendix B contains a representative "functional" scope trace.

3.10.4 Post Fire Results/Nut Separation

After examination of the functional hardware tests 45, 46 and 47, the following observations were made:

A) Nut separation at the defined break plane was complete.

B) After separation, the nut was in two (2) major pieces.

C) Comparison of damage sustained at the break plane is consistent with present D-LAT post fire examination.

D) Comparison of residual debris is comparable to present D-LAT post fire results.

4.0 CONCLUSIONS

After analysis of results obtained from this test program, it has been demonstrated that the program objectives have been fullfilled:

A) Provides an explosive cross-over between boosters.

B) Function time between boosters to be less than one (1) millisecond.

C) Cost savings for manufacture and acceptance testing of the booster.

D) System is compatible with existing frangible nut system.

E) System meets post-separation performance criteria.

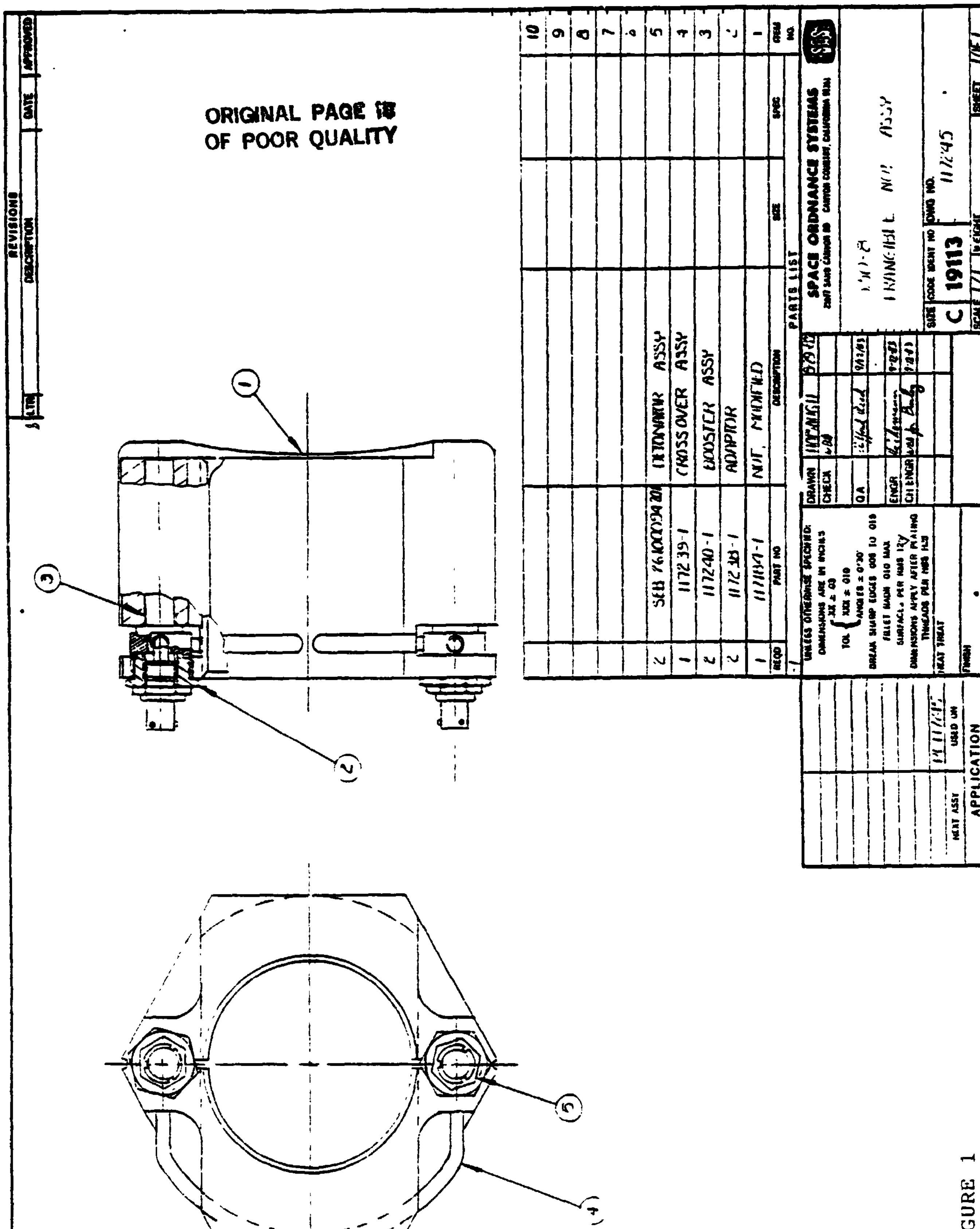
5.0 RECOMMENDATIONS

The following recommendations are offered for NASA consideration and future implementation:

A) Requirements for a booster cross-over assembly be incorporated into current specifications;

B) Allow use of MDF booster design as evaluated as part of this program; and

C) A "qualification" or "mini qual" program be completed so that future frangible nut systems can be furnished that reflect the design evaluated during this program.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DETONATOR ASSY
CROSSOVER ASSY
BOOSTER ASSY
ADAPTOR
NUT, MODIFIED
117239-1
117240-1
117238-1
117184-1
SPACE ORDNANCE SYSTEMS
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19113
117245
APPLICATION

FIGURE 1

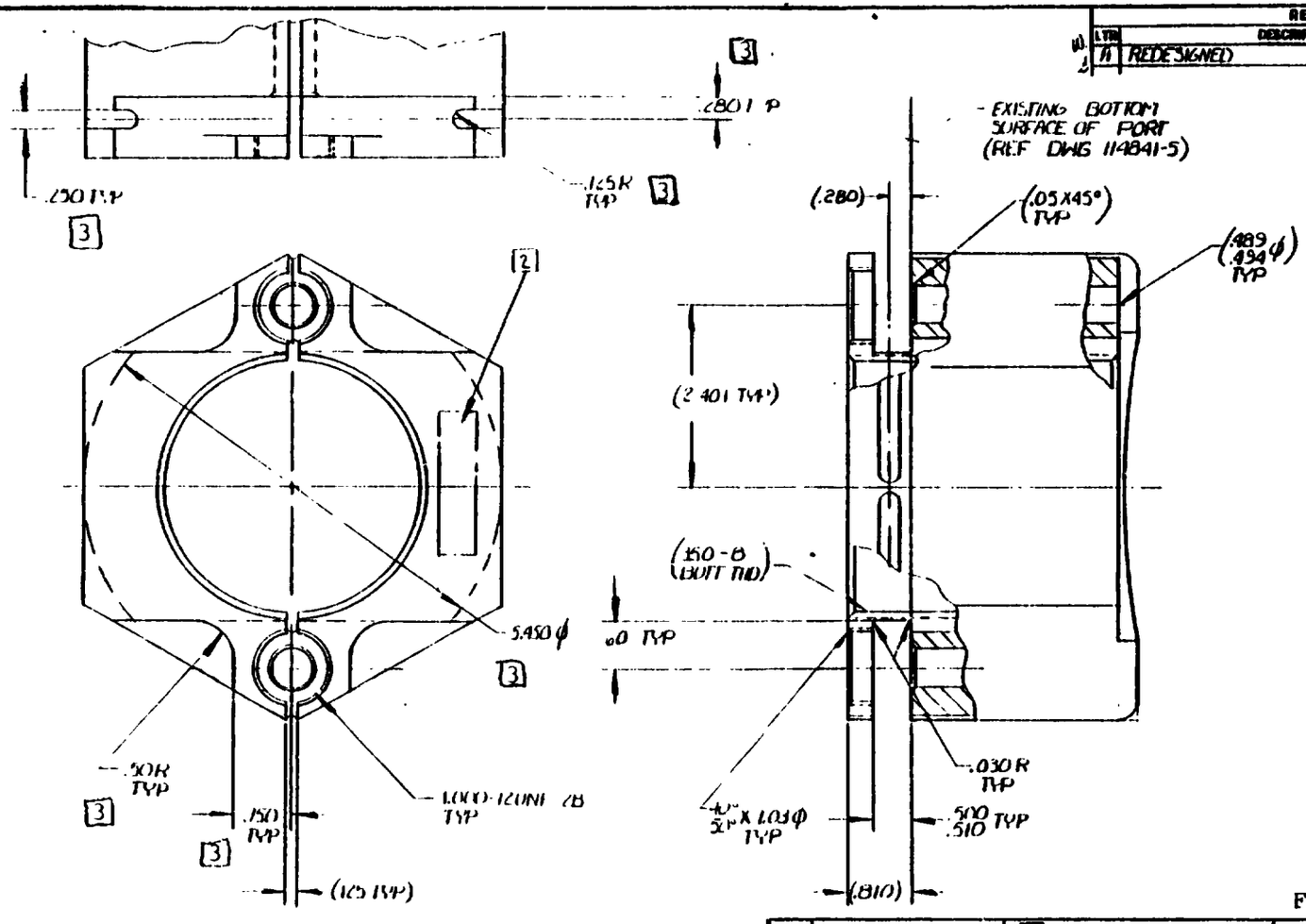

FIGURE 2

[3] PART OF PROPOSED DESIGN BUT NOT PART OF NUT MODIFICATION USED IN THIS PROGRAM

[2] ELECTRO ETCH/VIBRO ETCH PART NO. IN LOCATION SHOWN.

[1] MAKE FROM 114841-5 (HARDNESS RC 39-43)

NOTES

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	REDESIGNED	10/23/80	[illegible]

REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO
-1	[1]				1

PARTS LIST

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES; TOL { .XX ± .03, .XXX ± .010, ANGLES ± 0°30'; BREAK SHARP EDGES .006 TO .015; FILLET RADII .010 MAX; SURFACES PER MIL STD 129; DIMENSIONS APPLY AFTER PLATING; THREADS PER MIL STD H28; HEAT TREAT; FINISH

DRAWN	[illegible]	6-8-81
CHECK	[illegible]	6-11-81
QA	[illegible]	6/12/81
ENGR	[illegible]	6-19-81
CH ENGR	[illegible]	6/19/81

SPACE ORDNANCE SYSTEMS
21421 SAND CANYON RD. CANYON COUNTRY, CALIFORNIA 91351

150-8
FAIRING NUT MODIFICATION

SIZE	CODE IDENT NO	DWG NO.
C	19113	117184

SCALE 1/1 WEIGHT SHEET 1 OF 1

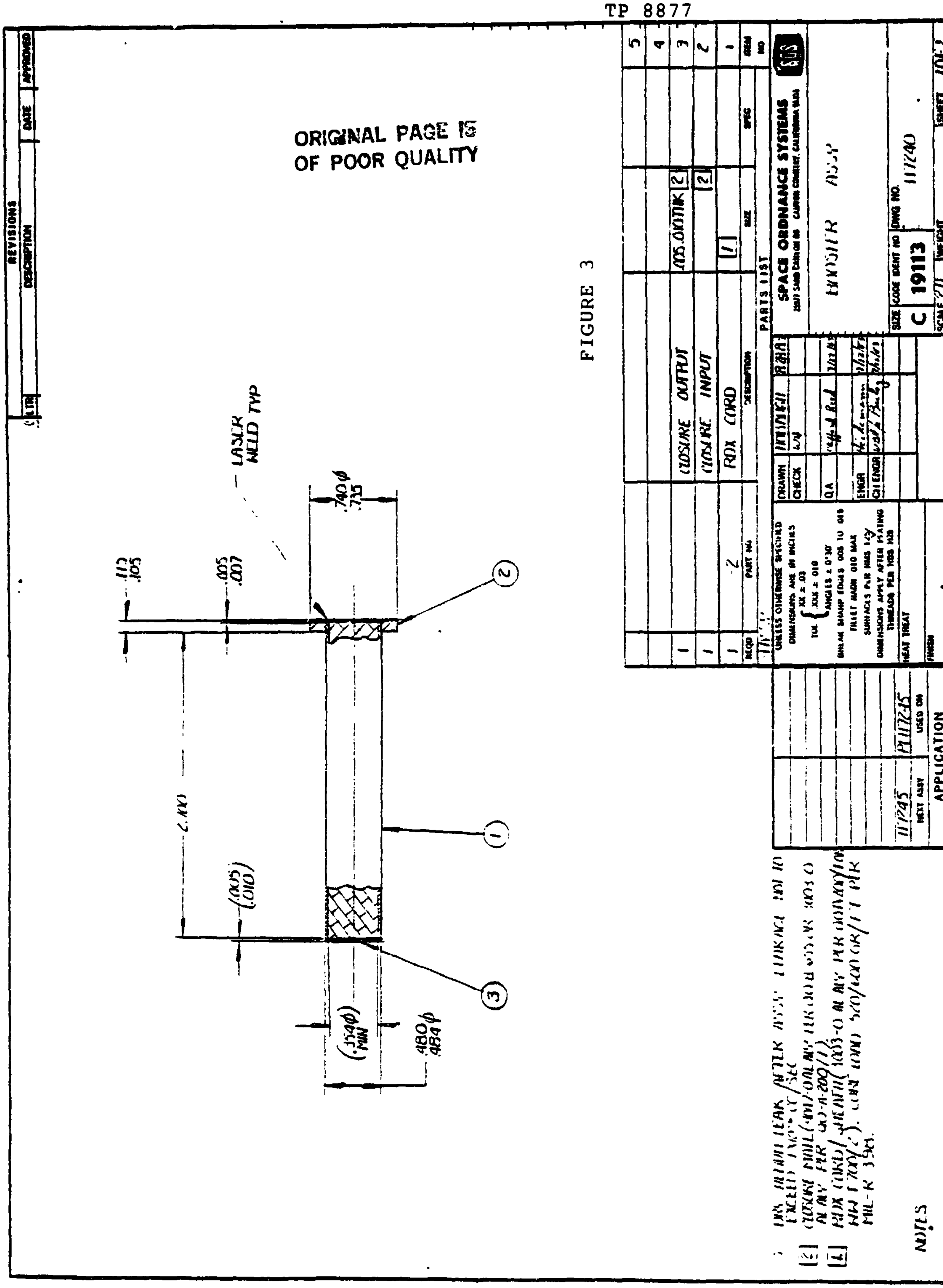
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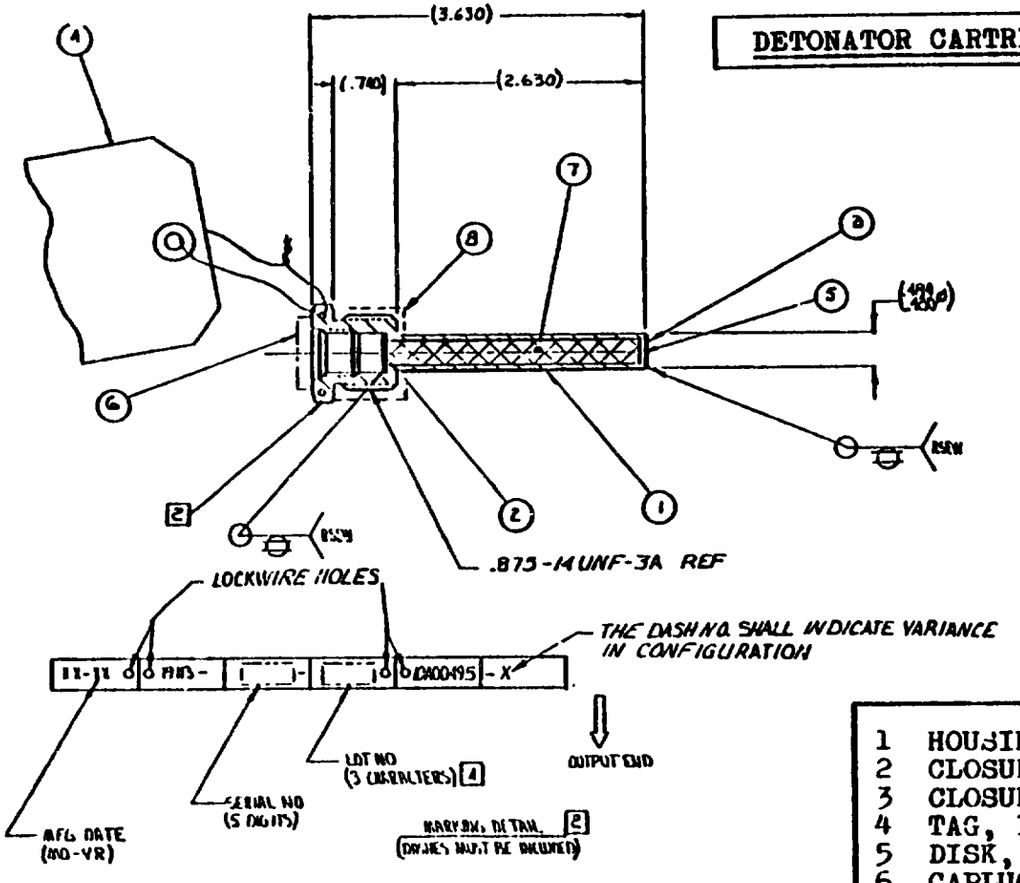
FIGURE 3

DETONATOR CARTRIDGE FOR 3.5-INCH FRANGIBLE NUT

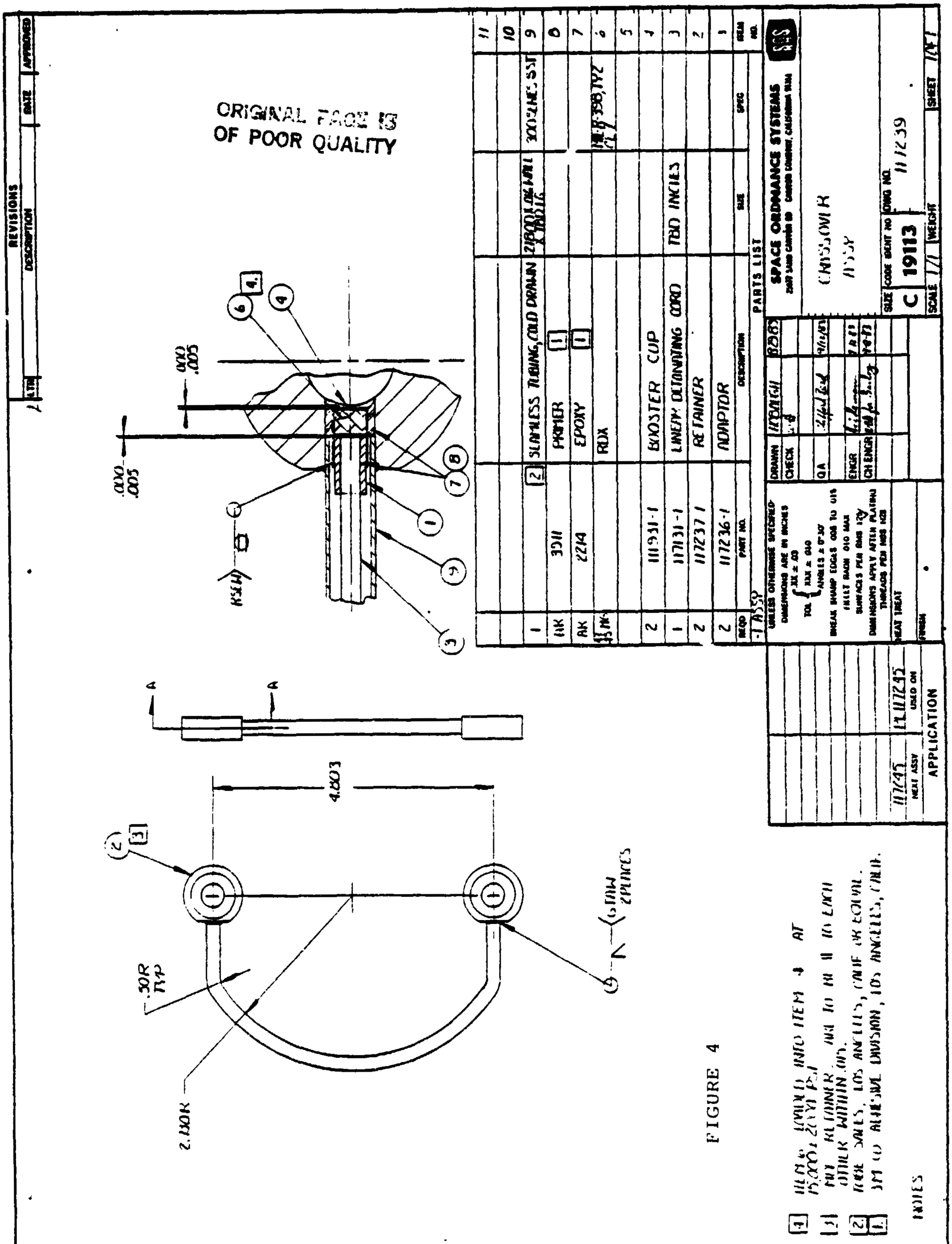


1	HOUSING	114847-1
2	CLOSURE DISK, INPUT	114993-1
3	CLOSURE DISK, OUTPUT	1-375-9
4	TAG, IDENTIFICATION	115322-1
5	DISK, ISOMICA	1-285-46
6	CAPLUG	PD-60
7	MAIN CHARGE	RDX (7250 mg)
8	CAPLUG	115237-1

BOOSTER ASSEMBLY
114848-3

FIGURE 3a

EXISTING BOOSTER DESIGN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SPACE ORDNANCE SYSTEMS
SEAMLESS TUBING, COLD DRAWN
PRIMER
EPOXY
RDX
BOOSTER CUP
LINEAR DETONATING CORD
RETAINER
ADAPTOR
TBD INCHES
C 19113
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NEXT ASSY
USED ON
4.803
.30R TYP
2.100R
NOTES

FIGURE 4

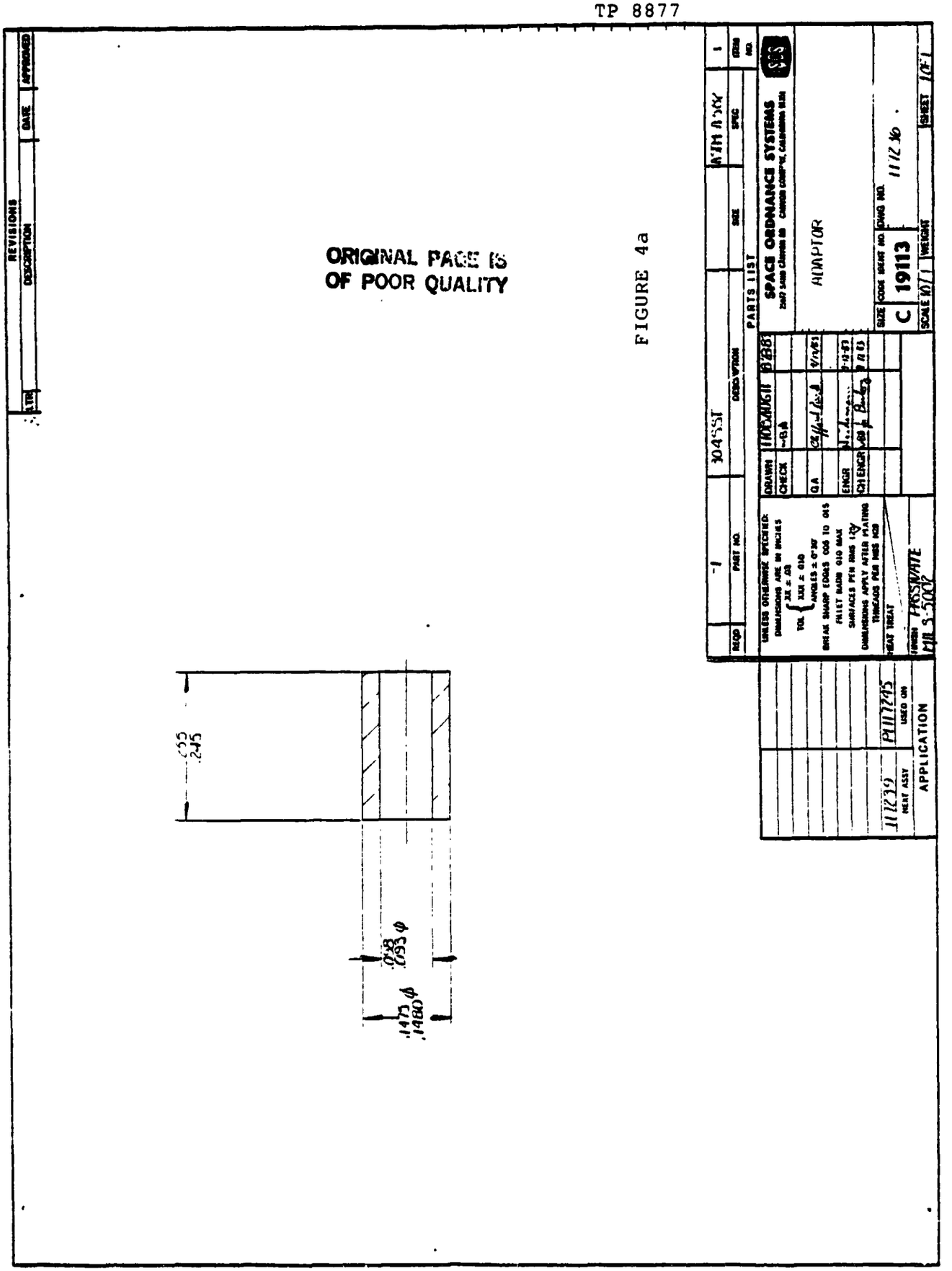

FIGURE 4a

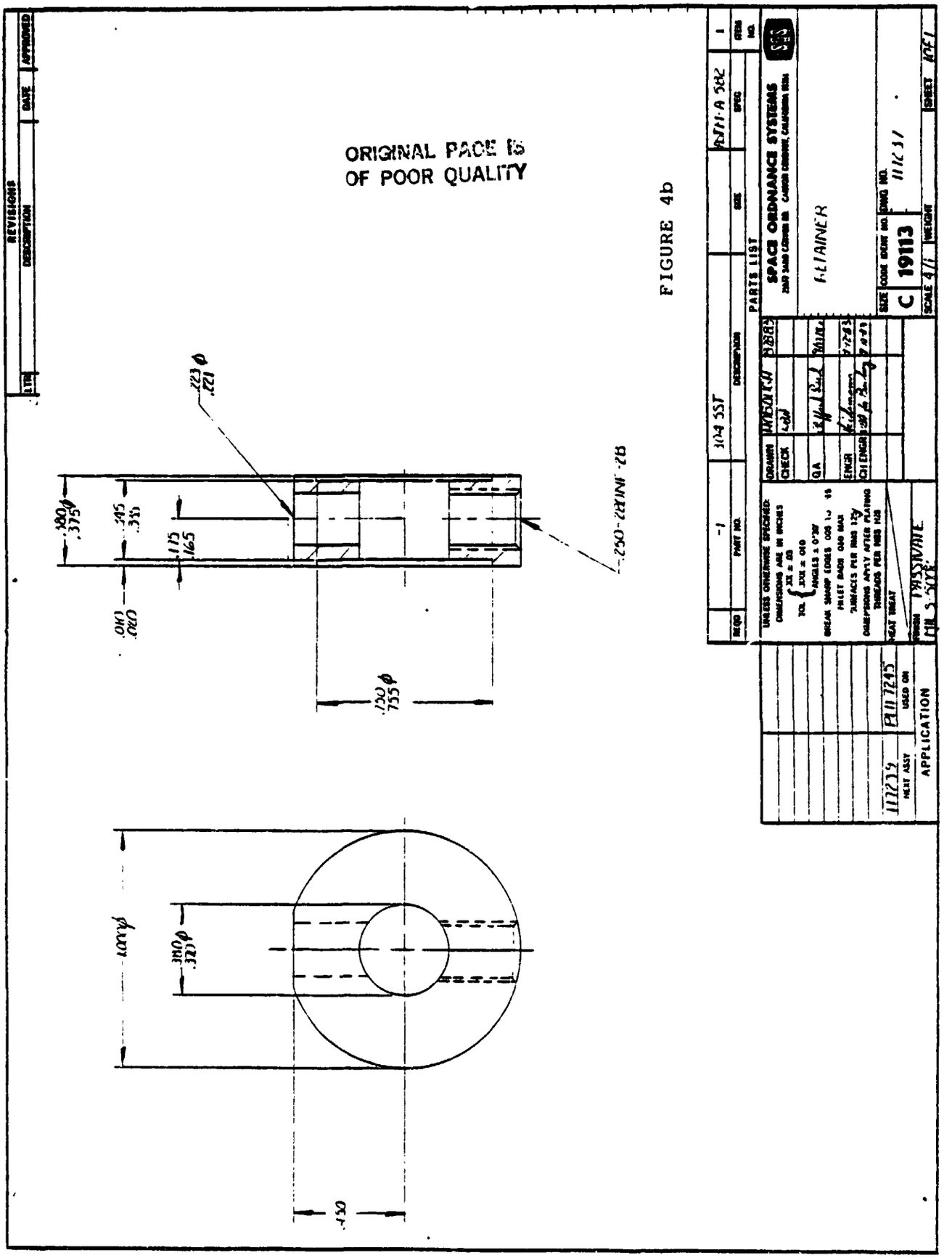
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FIGURE 4b

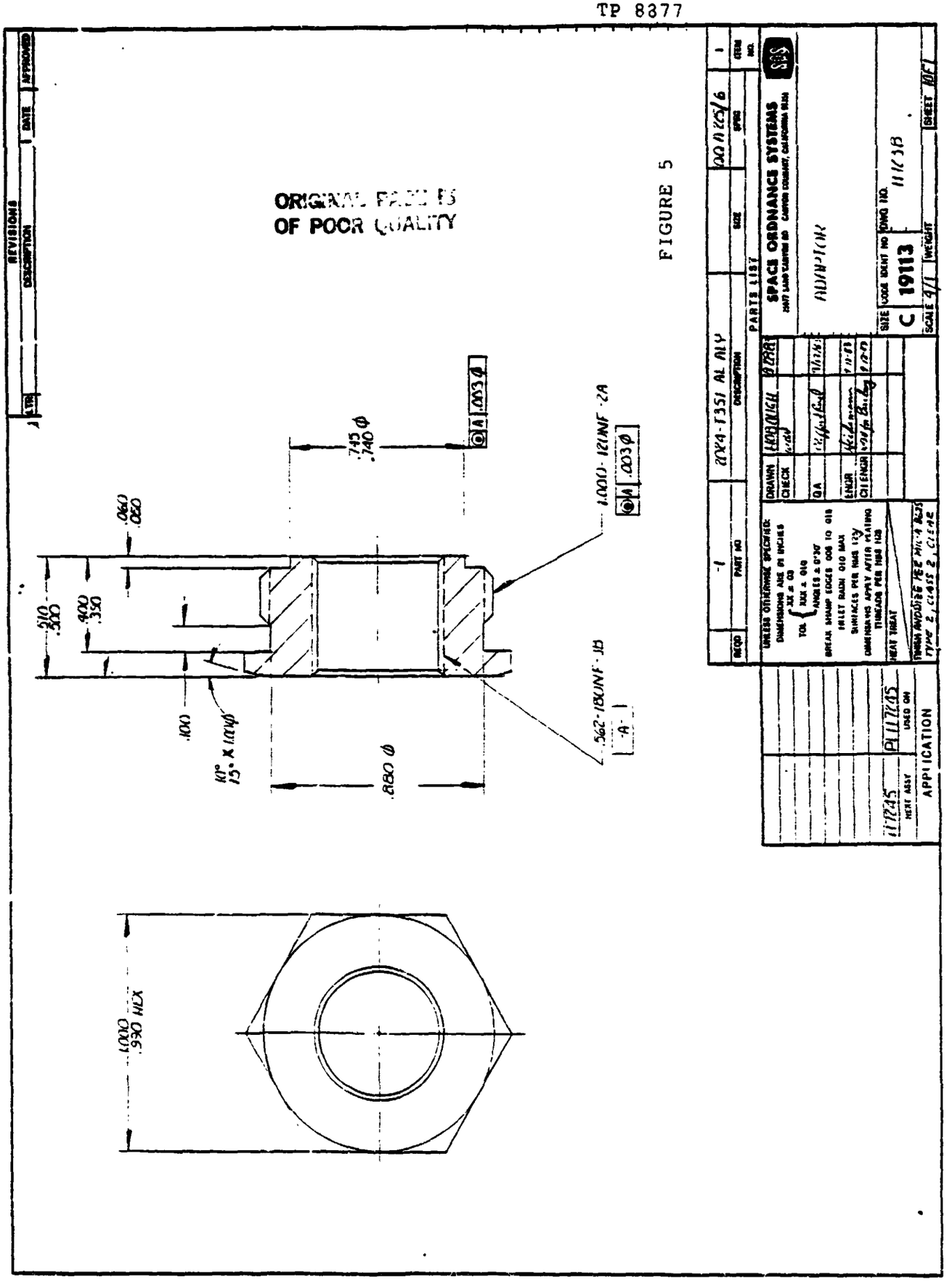
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FIGURE 5

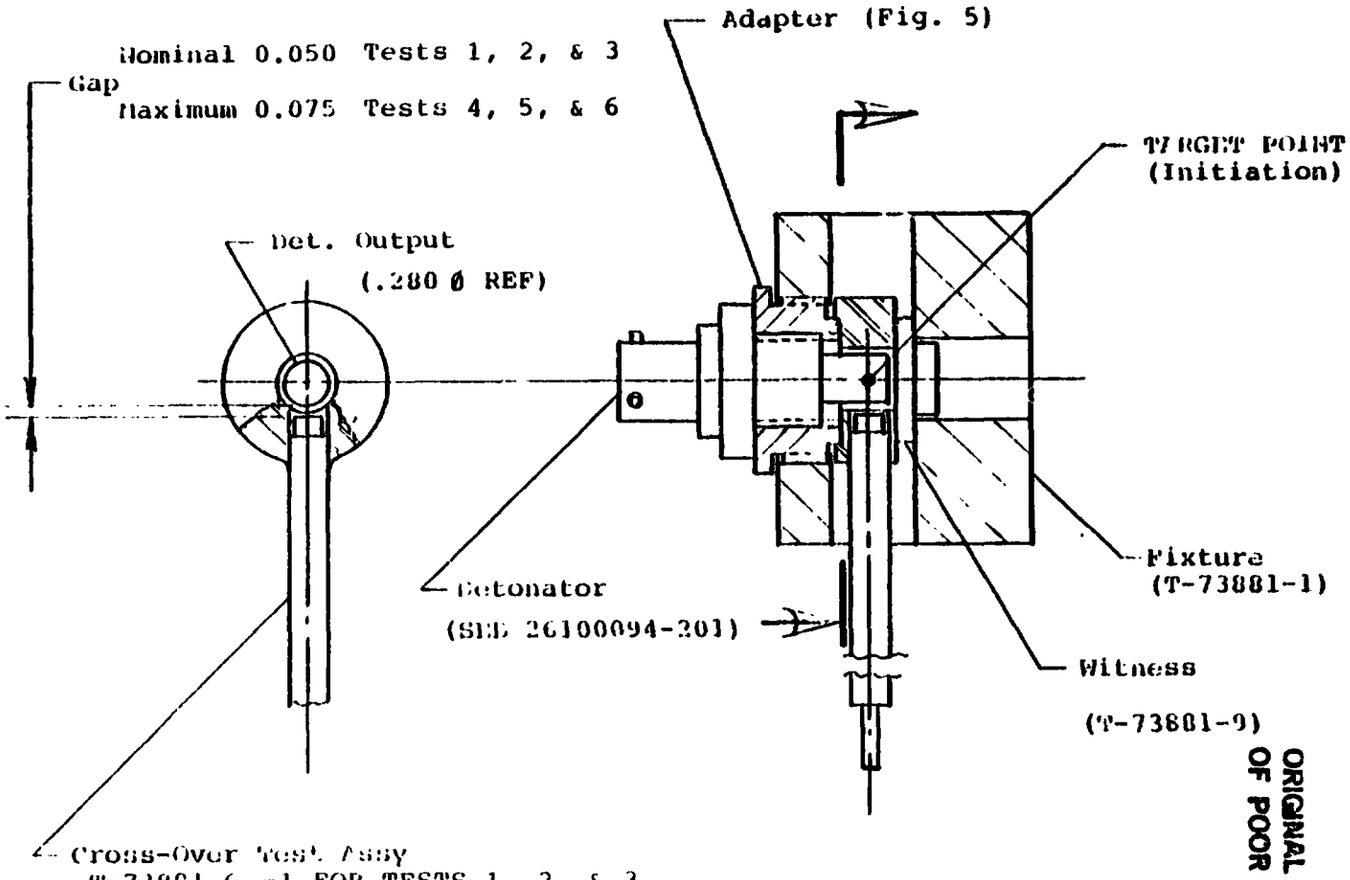


FIGURE 6

DETONATOR/CROSS-OVER TEST SET-UP

(DETONATOR AS DONOR)

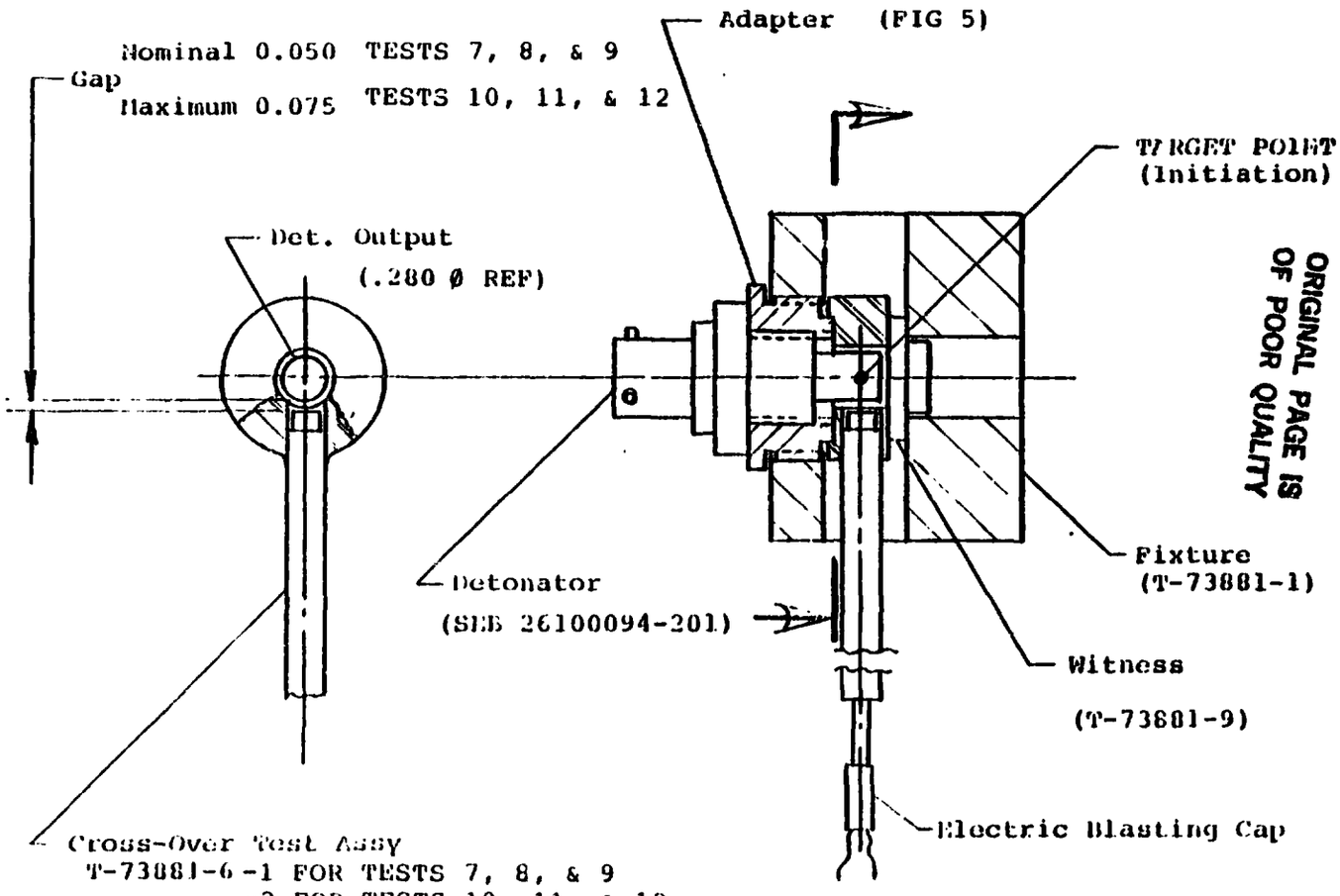
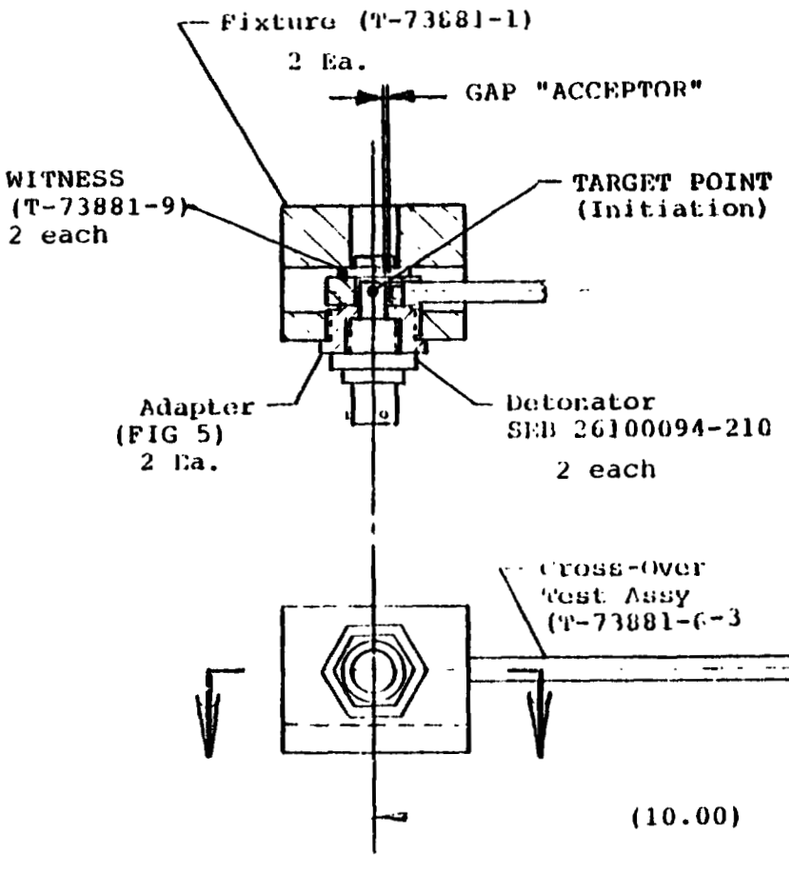


FIGURE 7

DETONATOR/CROSS-OVER TEST SET-UP
(CROSS-OVER AS DONOR)



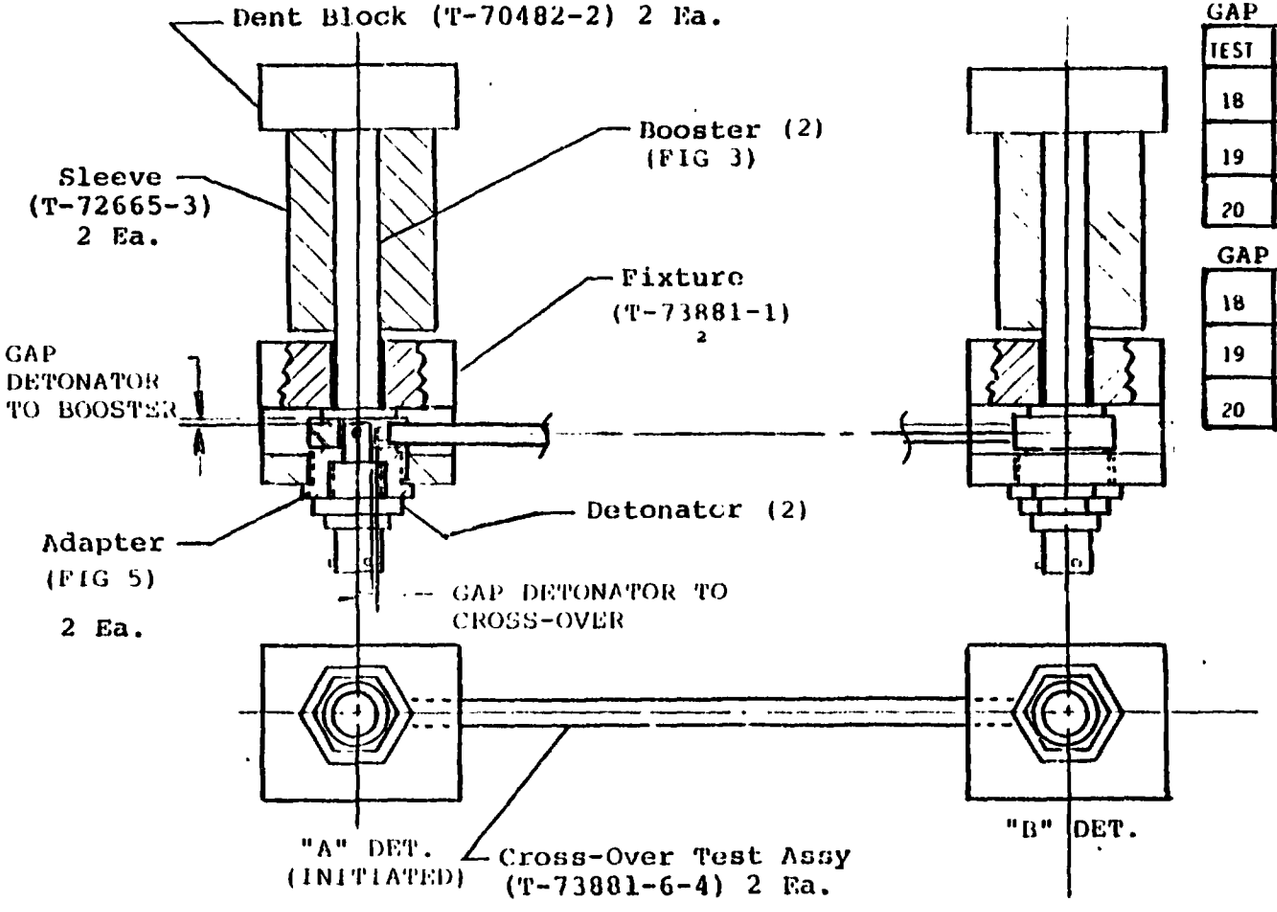
ACTUAL GAP (INCH)		
TEST No	ACCEPTOR	DONOR
13	.054	.051
14	.080	.068
15	.079	.083
16	.092	.048
17	.107	.083

FIGURE 8
TEST SET-UP

DETONATOR/CROSS-OVER/DETONATOR

(Note: Test Assembly T-73881-6-3 has 85% of nominal output charge)

SOS



GAP "A" DETONATOR

TEST	BOOSTER	CROSS-OVER
18	.048	.051
19	.048	.056
20	.047	.058

GAP "B" DETONATOR

18	.052	.052
19	.047	.054
20	.048	.056

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Figure 9

FULL SCALE PROPAGATION TEST SET-UP

(Dual Detonators & Boosters)

SOS

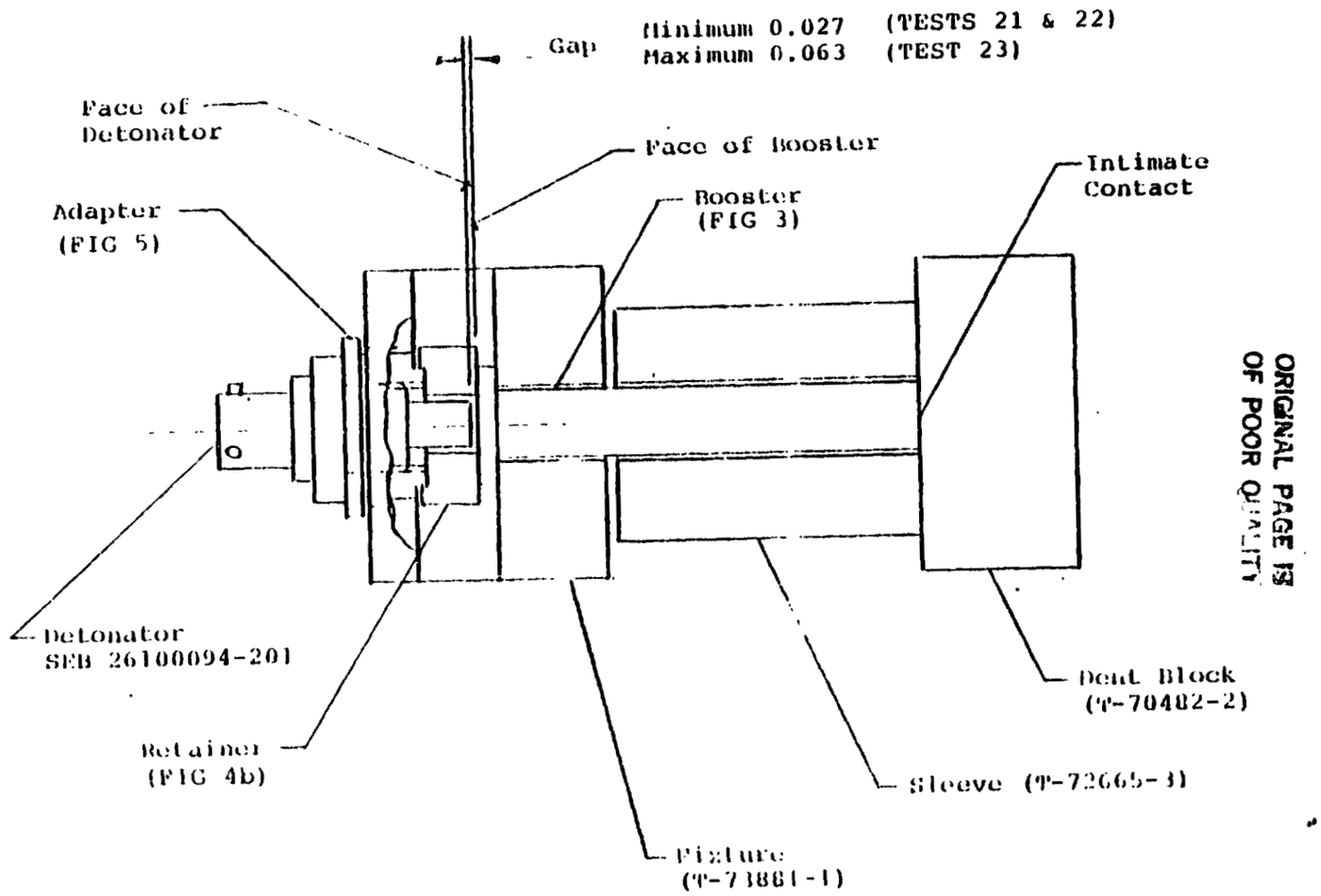
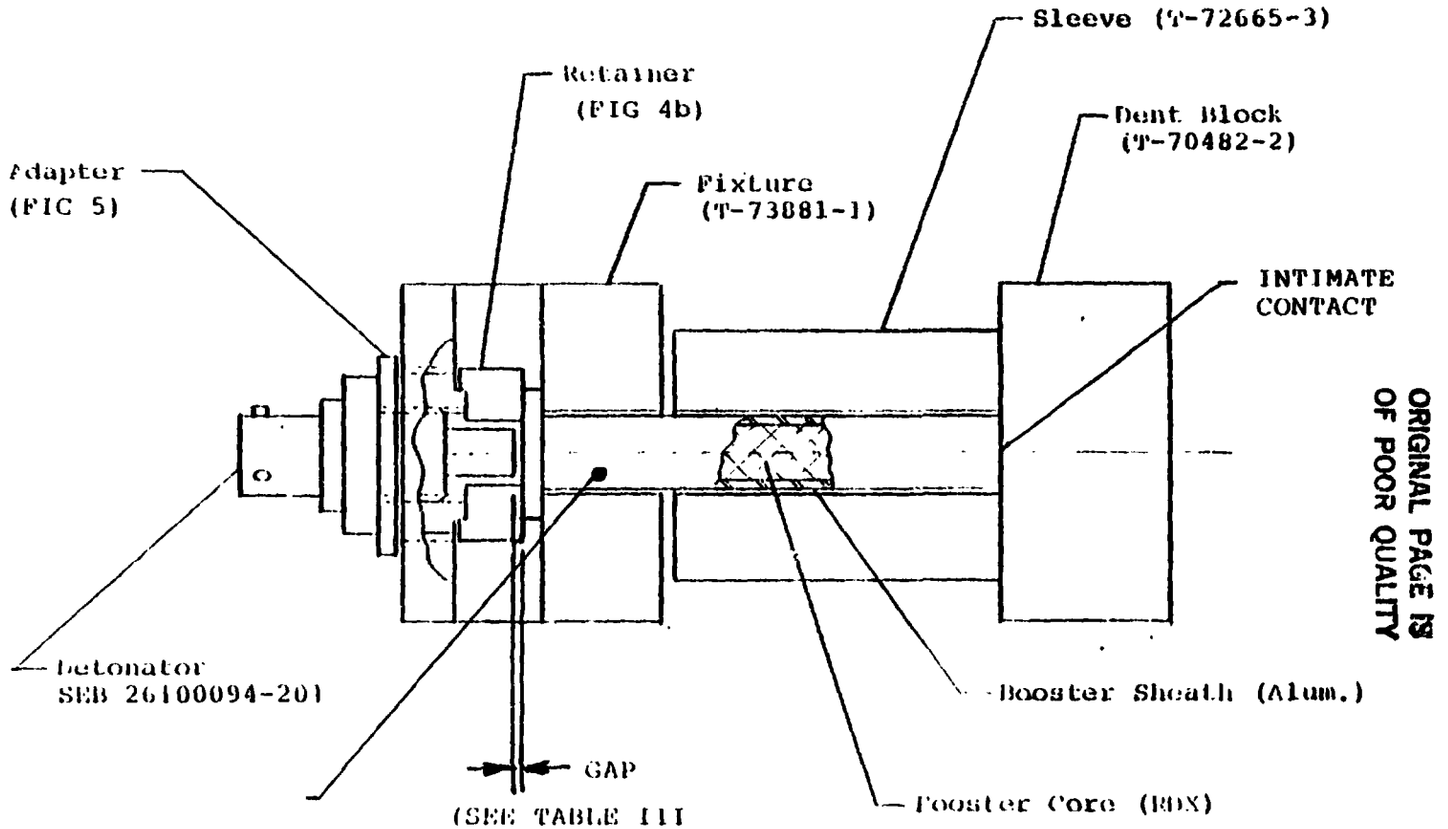


FIGURE 10

DETONATOR TO BOOSTER TEST SET-UP

SEE TABLE III FOR PLATE DENT DATA



TEST	
24	
25	MIN. 530 gr./Ft.
26	
27	
28	MAX 553 gr./ft.
29	

FIGURE 11

BOOSTER PERFORMANCE TEST SEC-GP
(SEE TABLE III FOR PLATE DENT DATA)

SOS

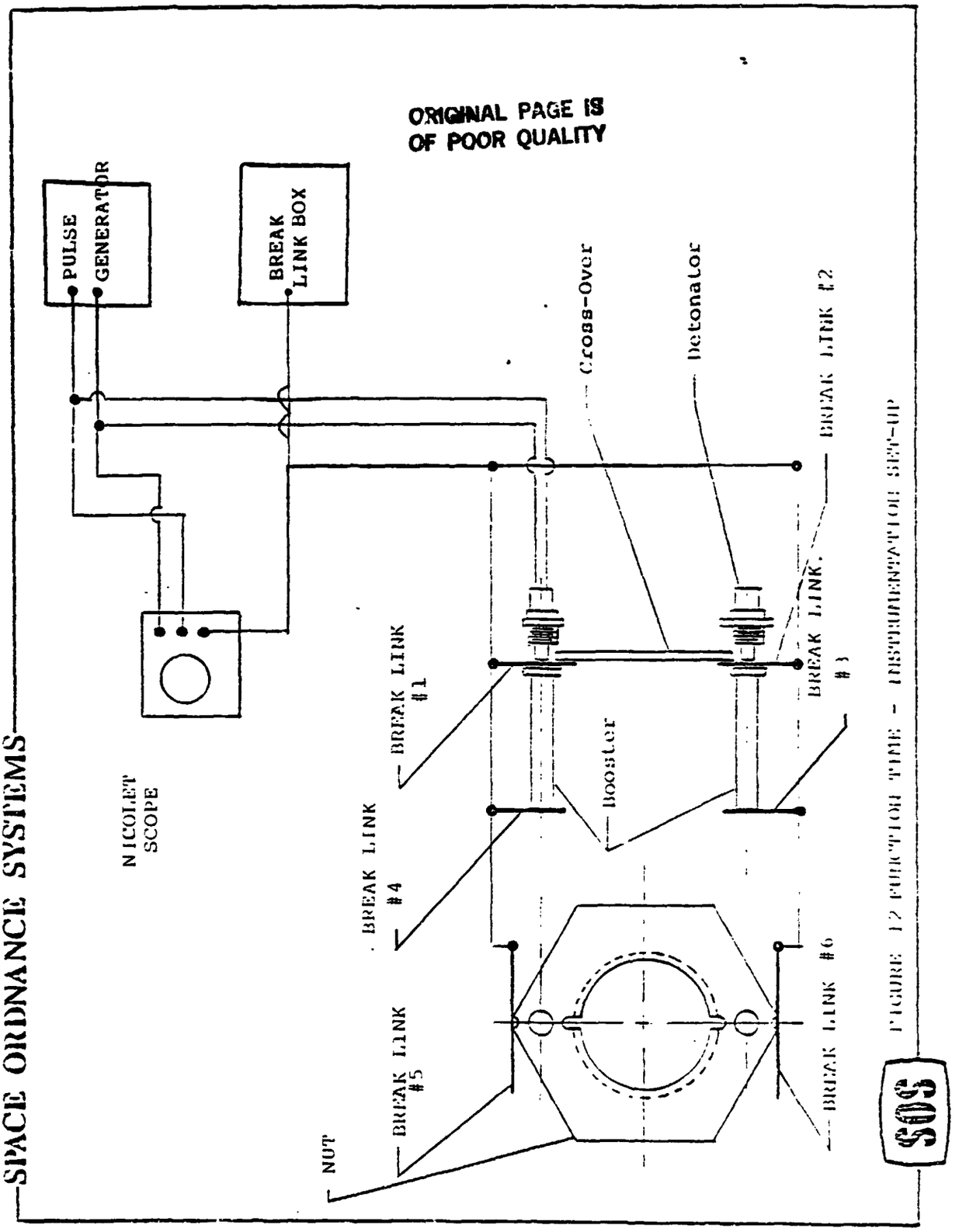


FIGURE 12 FUNCTION TIME - INSTRUMENTATION SET-UP

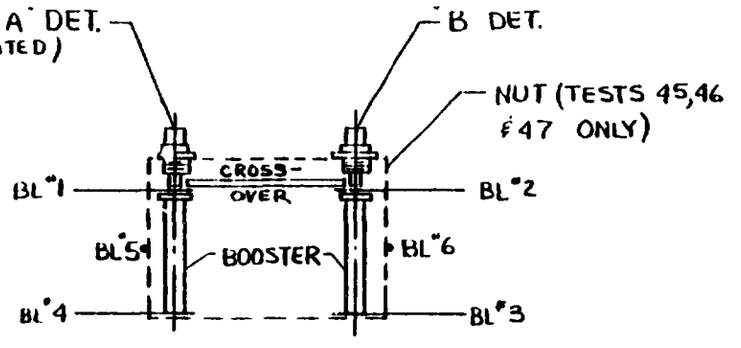
TEST SUMMARY TABLE I

TP 6877

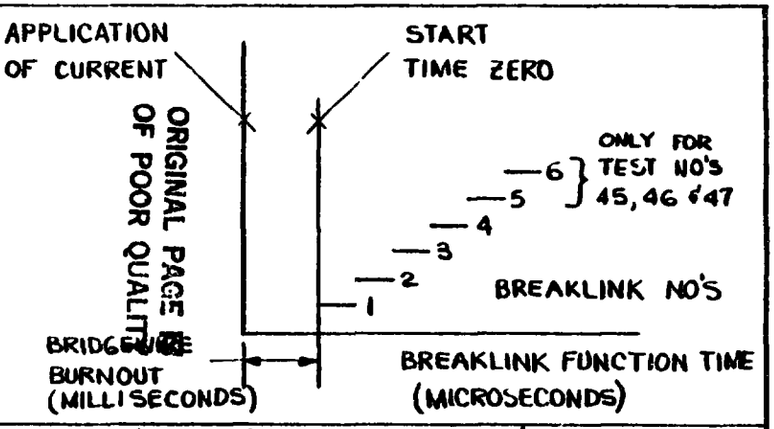
System	Test No.	Test Description	Test Set-Up Fig.	Detonator S/N Location A	Detonator S/N Location B	Remarks
Cross-Over	1	Detonator/Cross-Over Test. Detonator as Donor (Nom. Gap 0.050 in)	6	371		All Specimens Functioned Successfully
	2			356		
	3			316		
	4	Detonator/Cross-Over Test. Detonator as Donor (Max. Gap 0.075 in)		361		
	5			352		
	6			370		
	7	Detonator/Cross-Over Test. Cross-Over as Donor (Nom. Gap 0.050 in)	7	367		All Specimens Functioned Successfully
	8			366		
	9			362		
	10	Detonator/Cross-Over Test. Cross-Over as Donor (Max. Gap 0.075 in)		368		
	11			364		
	12			373		
	13	Detonator/Cross-Over/Detonator; Initiate One(1) Detonator; Cross-Over at 85% Nominal Output Charge	8	319	351	See Fig. 8 For Actual Gaps At Interfaces. See Table II For Function Time Data
	14			358	374	
	15			353	363	
	16			365	355	
	17			360	359	
	18	Full-Up Propagation. Dual Detonators/Boosters. Initiate One(1) Detonator	9	339	314	See Fig 9 For Gap Data; See Table II For Funct. Time; See Table III For Dent Data
	19			315	313	
	20			336	312	
Booster	21	Detonator To Booster (Min. Gap 0.027 in)	10	338		See Table III For Gap And Plate Dent Data
	22			343		
	23	(Max. Gap 0.063 in)		344		
	24	Booster Performance (Minimum MDF Core Load)	11	346		See Fig 11 For Core Load Data. See Table III For Gap And Plate Dent Data
	25			342		
	26			335		
	27	(Maximum MDF Core Load)		345		
	28			354		
	29			337		
	30 to 44	Booster Performance Acceptance Criteria	N/A			Summary Of Data From Tests 18-29. See Table III
Nut	45	Verification - Full-Up Nut System	12	348	341	See Table II For Gap And Function Time Data
	46			340	318	
	47			317	350	

FUNCTION TIME - TABLE II.

TP 8877



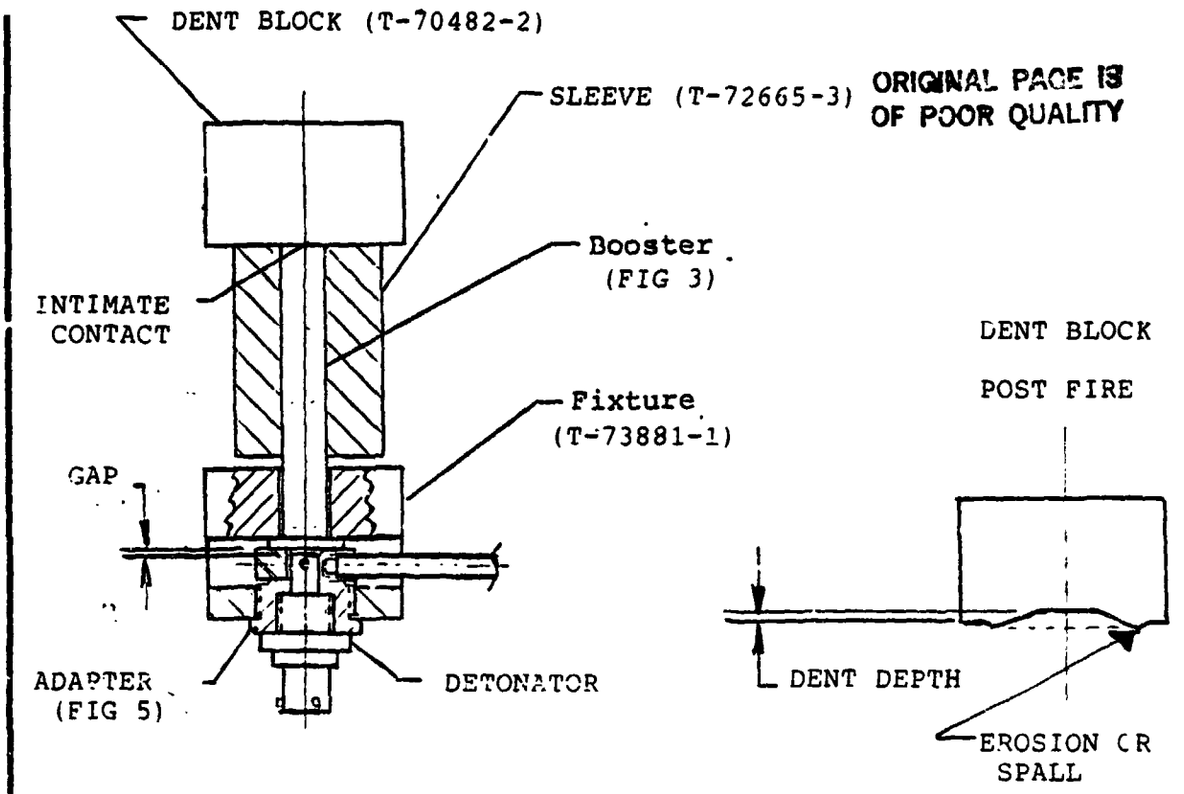
BREAKLINK (BL) LOCATIONS



TEST NO.	TEST SET-UP: DETONATOR S/N A	DETONATOR S/N B	ACTUAL GAP (INCH) DETONATOR TO "A" DET BOOSTER	"A" DET X OVER	"B" DET BOOSTER	"B" DET X-OVER	"A" DET B/W BURN OUT M SEC	FUNCTION TIME (μ SEC): TIME ZERO TO BL # 1	2	3	4	5	6	BREAKLINK # __ To BREAKLINK # __: 1-4	1-2	2-3	3-4	BETWEEN 5&6	BETWEEN 4&5	BETWEEN 3&6	REMARKS
13	319	351	N/A	.054	N/A	.051	LOST		DATA													NO SCOPE TRIGGER
14	358	374	.051	.080	.046	.068	1.19	8	356	428	168			160	348	72	260					
15	353	363	.049	.014	.050	.083	1.22	58	462	528	302			244	404	66	226					
16	365	355	.048	.092	N/A	.048	1.20	38	65	92	N/A			N/A	27	27	N/A					BOOSTER "A" SIDE NOT IN TEST SET-UP
17	360	359	N/A	.107	N/A	.083	1.18	6	240	N/A	N/A			N/A	234	N/A	N/A					BOOSTER'S NOT IN TEST SET-UP
18	359	314	.048	.051	.052	.052	1.11	6	88	120	68			60	82	32	52					
19	315	313	.048	.056	.047	.054	1.28	4	84	92	74			70	80	8	18					
20	336	312	.047	.058	.048	.056	1.21	20	102	240	68			48	82	138	112					
45	348	341	.051	.075	.049	.052	1.19	2	50	92	20	132	136	18	48	42	72	4	112	49		
46	340	318	.047	.052	.050	.054	1.17	2	56	90	16	--	-	14	54	34	74	—	—	—		LOST DATA BREAK LINES 5 & 6
47	317	350	.052	.054	.050	.056	1.20	22	116	132	50	356	360	28	104	6	82	4	306	228		

BREAKLINK FUNCTION

#1 SENSE "A" DET. OUTPUT
#2 SENSE "B" DET. OUTPUT
#3 SENSE "B" BOOSTER OUTPUT
#4 SENSE "A" BOOSTER OUTPUT
#5 SENSE "A" SIDE NUT SEP.
#6 SENSE "B" SIDE NUT SEP.



TEST NO.	DET. S/N	GAP DET. TO BOOSTER	PLATE DENT (INCH)
18	339	.048	.129
	314	.052	.129
19	315	.048	.132
	313	.047	.130
20	336	.047	.131
	312	.048	.128
21	338	.027	.134
22	343	.027	.133
23	344	.063	.132
24	346	.063	.134
25	342	.048	.133
26	335	.046	.132
27	345	.027	.136
28	354	.046	.136
29	337	.049	.134

DENT REQUIREMENT

0.078 INCH MINIMUM

THESE 15 TESTS

$\bar{x}$ 0.132

MIN 0.128

MAX 0.136

D-LAT (LOT AAF) EXISTING DESIGN 26 TESTS

$\bar{x}$ 0.126

MIN 0.113

MAX 0.146

TABLE III BOOSTER - PLATE DENT DATA

APPENDIX A

RELATED TEST FIXTURES AND TEST HARDWARE UTILIZED IN THESE TESTS

A-1 CROSS-OVER TEST ASSY T-73881-6-1 NOM LOAD/NOM GAP

A-2 CROSS-OVER TEST ASSY T-73881-6-2 NOM LOAD/MAX GAP

A-3 CROSS-OVER TEST ASSY T-73881-6-3 85% LOAD/NOM GAP

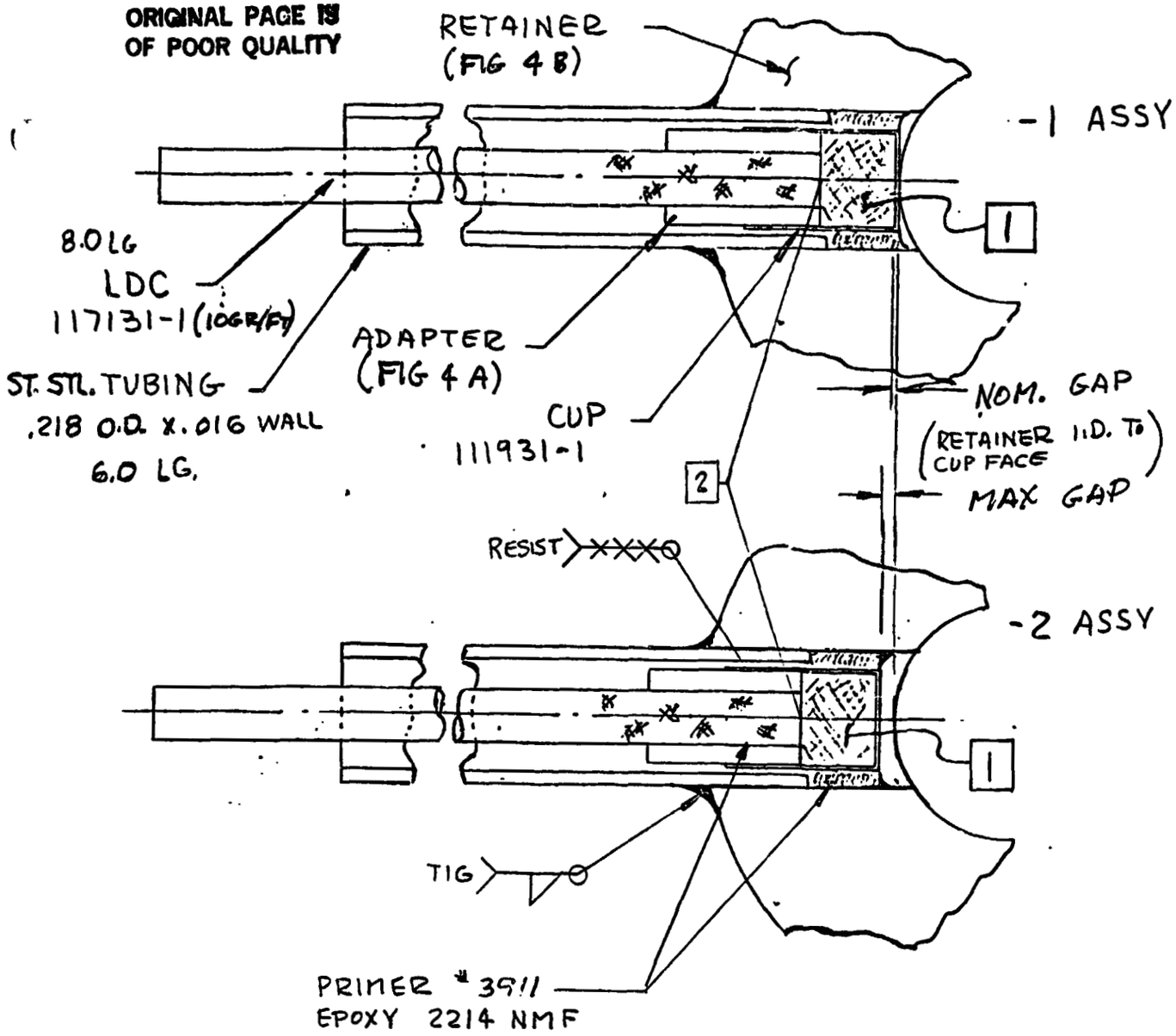
A-4 CROSS-OVER TEST ASSY T-73881-6-4 FULL UP CONFIGURATION

A-5 FIXTURE - PORT SIMULATED T-73881-1

A-6 WITNESS -DETONATOR OUTPUT T-73881-9

A-7 SLEEVE - PLATE DENT T-72665-3

A-8 BLOCK - DENT TEST T-70482-2



[2] TRIM LDC FLUSH WITH ADAPTER AFTER BONDING.

[1.] RDX MIL-R-398 TYPE II, CL7
46 ±1mg LOADED WITH 280±10LBS

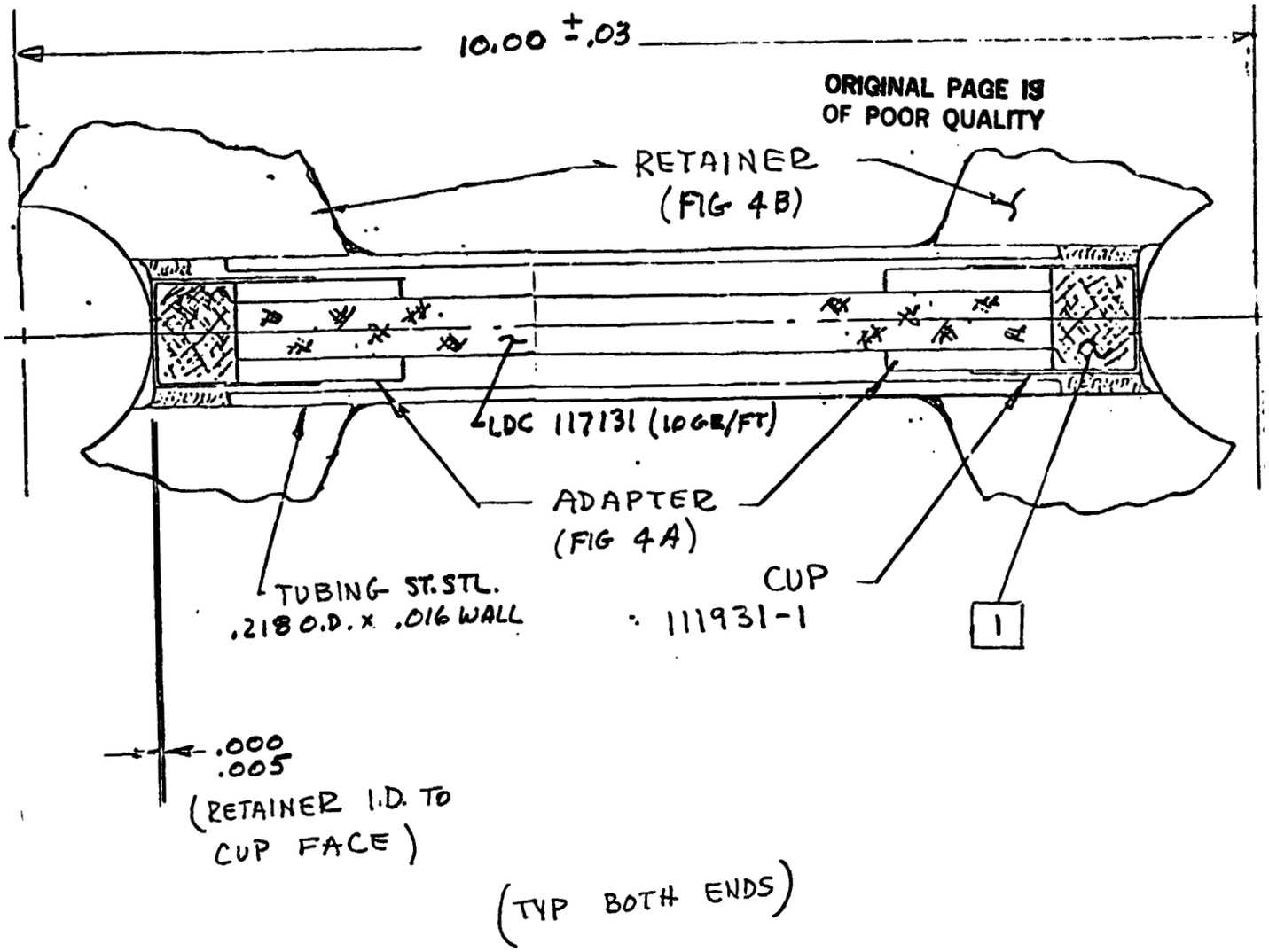
CROSS-OVER –
TEST ASSY

T-73881-6-1
& -2

NOTES

A-1 / A-2

WN 6/23/83

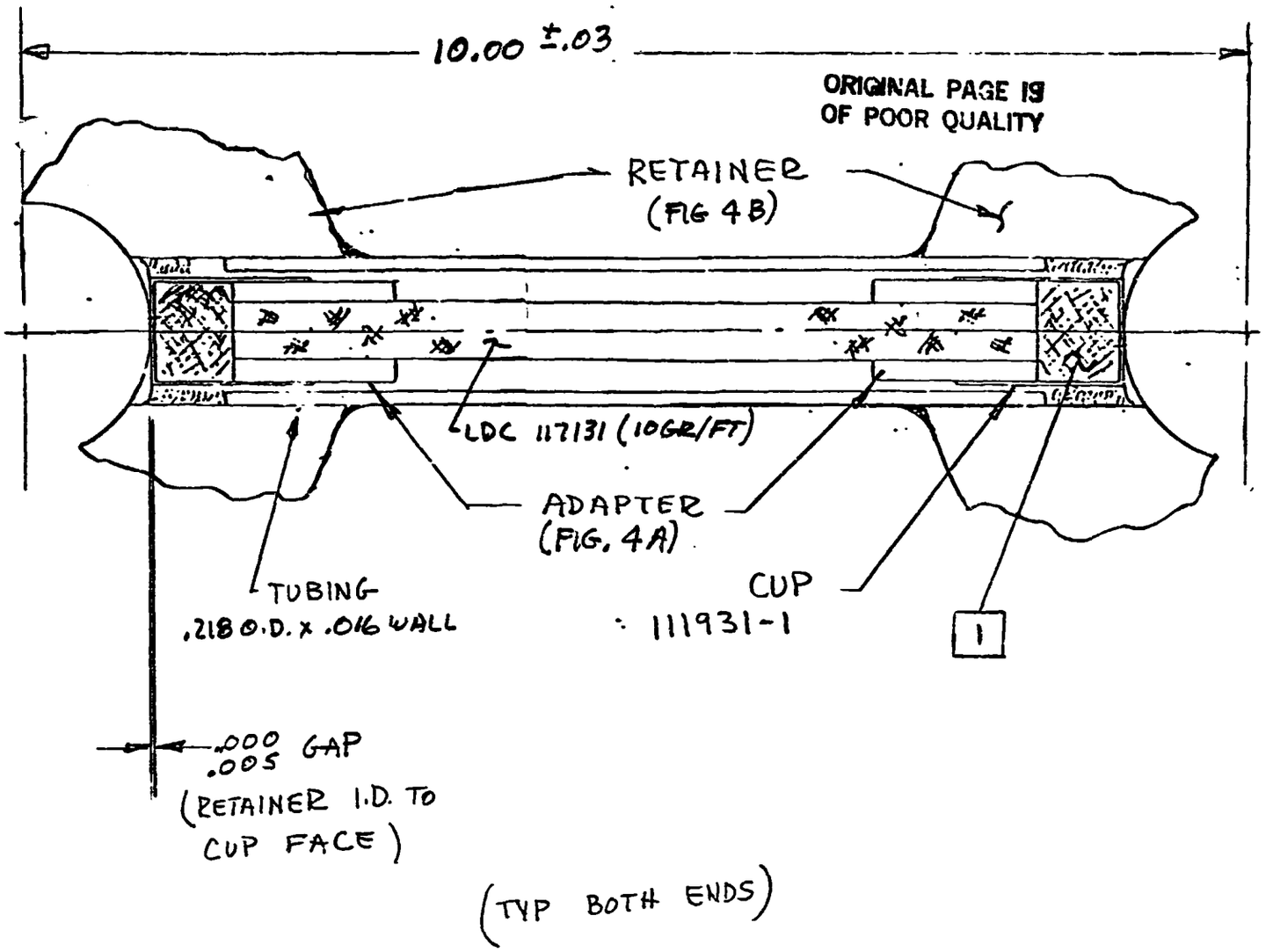


CROSS-OVER
TEST ASSEMBLY
T-73881-6-3
(85% OUTPUT CHARGE)
WH 6/24/83

[1] RDX MIL-R-398 TYPE II, CL 7
40 $\pm^{0}_{1}$ mg LOADED WITH 280 ±10LBS

NOTES

A-3



2 BENT AT ASSY. TO FIT FRANGIBLE NUT (REF FIG 4)

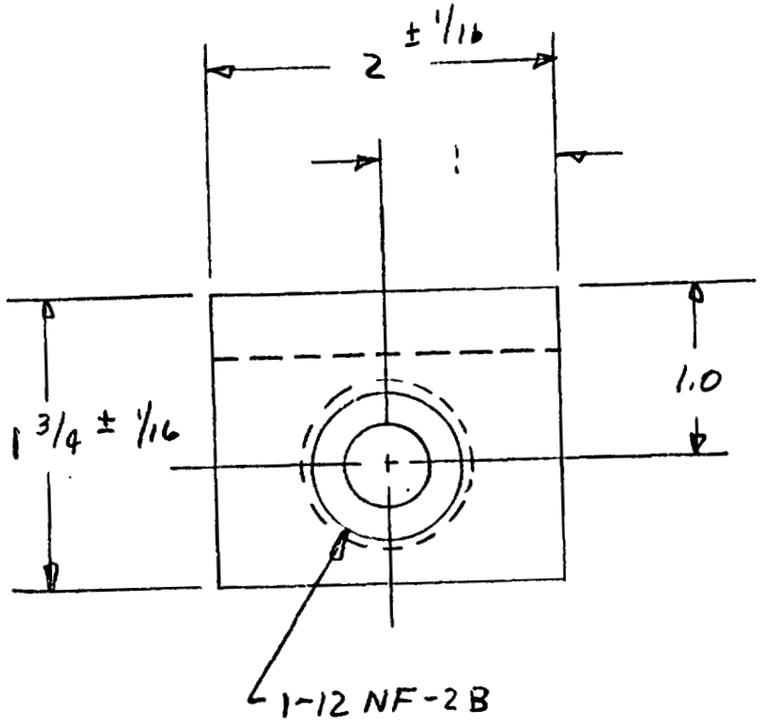
[1] RDX MIL-R-398 TYPE II, CL 7
46±1 mg LOADED WITH 280±10LBS

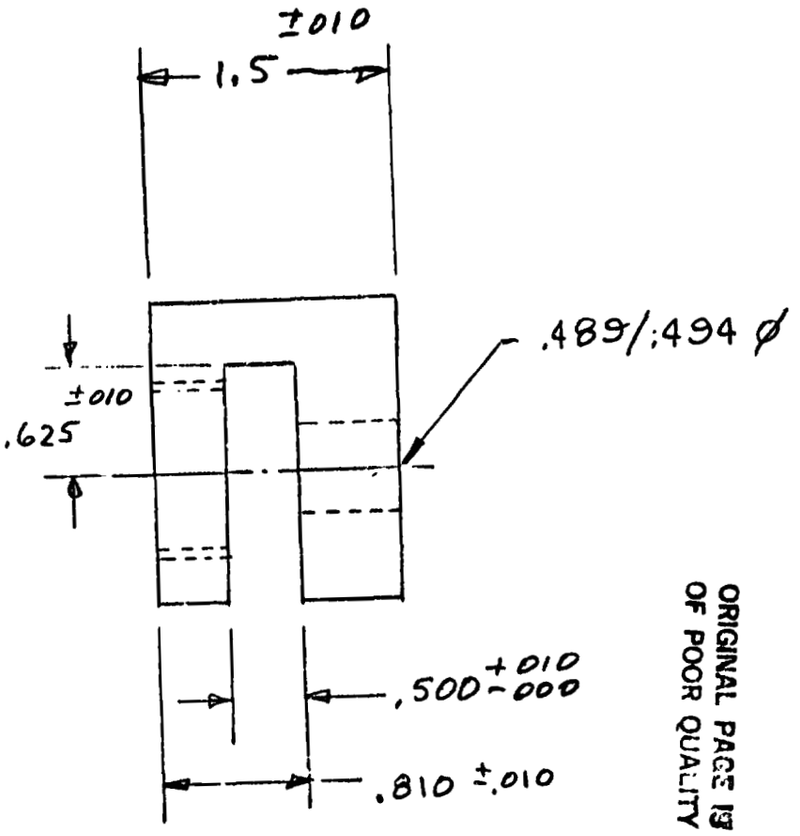
NOTES

CROSS-OVER
TEST ASSEMBLY
T-73881-6-4

WH 6/24/83

A-4





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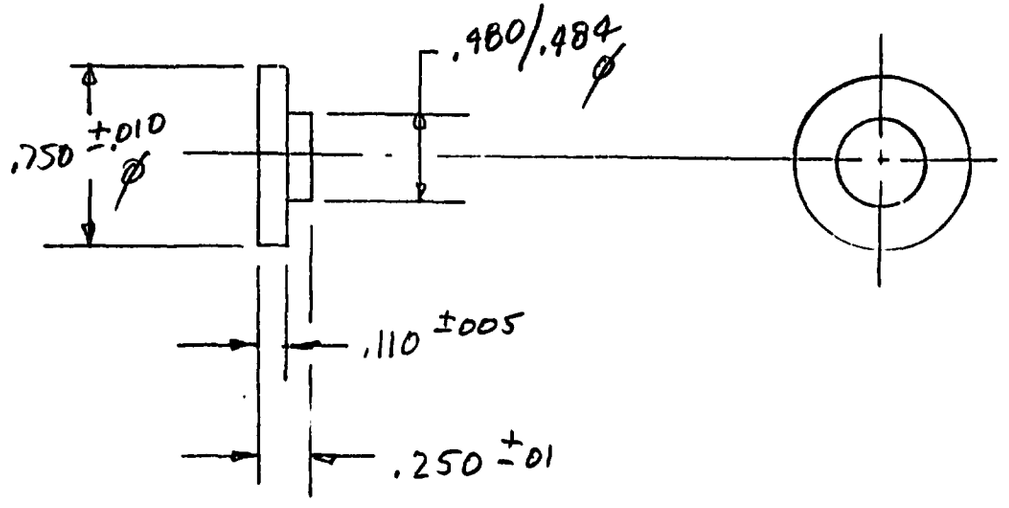
A-5

-40-

MAT'L: ALUM 2024-T351

FIXTURE
PORT SIMULATED
T-73881-1

WJ 5/10/83

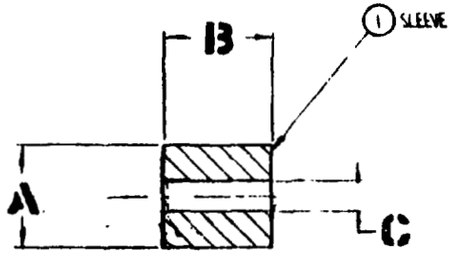


material : alum

Witness Plate -
Detonator Output
T-73881-9
WU 6/28/83

USED ON	DASH NO.	A ϕ	B	C ϕ
114500-1	-1	1250	1.035 / 1.016	.391 / .383
114848-1	-2	1.50	2.516 / 2.376	.485 / .497
116234-1	-3	1.50	2.125 / 2.150	.485 / .497

REVISIONS			
LTR	DESCRIPTION	D	APPROVED
A	DCN 63284	5-24-77	
B	DCN 65663	5-7-9	
C	DCN 68995	11/30/82	



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T-72665 D

-42- A-7

REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO.
	SEE TAB. BLOCK	HOUSE MATED PARTS	A ϕ STK	QQ-B-626	1

PARTS LIST

NEXT ASSY	USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOL { XX ± .03 / XXX ± .010 / ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER RMS 125
DIMENSIONS APPLY AFTER PLATING
THREADS PER MIL H28

HEAT TREAT

FINISH

DRAWN		1/25
CHECK		
QA		5-8-79
ENGR		5-14-79
CH ENGR		5/24/79

SPACE ORDNANCE SYSTEMS
25917 SAND CANYON RD CANYON COUNTRY, CALIFORNIA 91354

SLEEVE - DENT TEST, BOOSTER

SIZE	CODE IDENT NO	DWG NO.
C	19123	T-72665

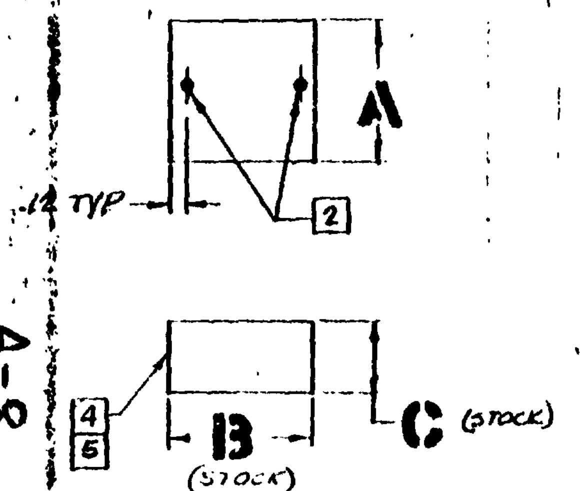
SCALE | WEIGHT | SHEET 1 OF 1

[1] IDENTIFY PARTS (INCLUDE DASH NO), METHOD & CHARACTER SIZE OPTIONAL.

NOTES:

DASH NO.	A	B	C	MAKE FROM SIZE
-1	1.30 / 1.20	1.30 / 1.20	.630 / .620	5/8 x 1 1/4 BAR
-2	2.00	2.00	1.00	1 x 2 - BAR

LETTER	CHANGE	DATE	EFFECTIVITY	BY	APPROVED
A	SEE DCN 50024		5/6		
B	SEE DCN 52930	5-24-67	5-24-67		
C	DCN 63285	5-26-79	5-26-79		
D	DCN 68164	11/17/81	11-24-81		



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5 MARK THREE DIGIT S/N (-2 ONLY) THIS AREA. S/N'S ARE NOT TO BE REPEATED (S/N'S SUPPLIED BY S.O.S. PROD. CONTROL).

4 MARK PART NO. THIS AREA. (IMPRESSION STAMP, ELECTROMARK, ELECTROETCH).

3. PART MUST BE MADE FROM RECTANGULAR STOCK.

2 HARDNESS: RB 70-95, MEASURED ON A ROLLED SURFACE, IN LOCATION SHOWN.

1. PART TO BE CLEAN & FREE FROM BURRS

NOTES:

PART NO.	NO. REQD.	DESCRIPTION	SIZE	SPEC.
SEE TAB.		1018 OR 1020 STL. BAR	SEE TAB	ASTM-A108

LIST OF MATERIAL

TOLERANCES UNLESS OTHERWISE SPEC. BREAK ALL SHARP CORNERS .015 MAX. CONCENTRICITY OF DIAMETERS .005 TIR. .XX ±.03 .XXX ±.010 ANGLES ±1/2° SURFACE 125 MAX. PER MIL STD-10 FILLET RADII .010 MAX. THREADS PER MIL-S-7742

DRAWN BY SCHOB — CHECKED — ENGR — Q.C.

SPACE ORDNANCE SYSTEMS
135 PENN STREET
EL SEGUNDO, CALIFORNIA

CODE IDENT. NO. 19113

TITLE: BLOCK - DENT TEST

DWG. NO. T-70482 REV. D

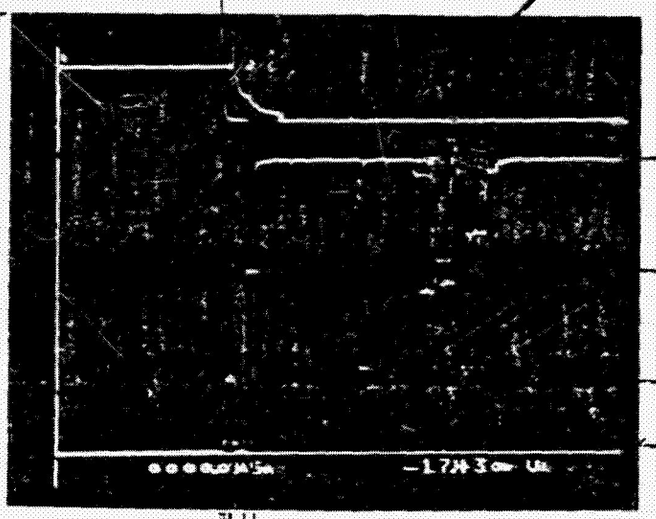
SCALE 1/1

O.D. Tool No. T-604

A-8

APPENDIX B

B-1 REPRESENTATIVE FUNCTIONAL TEST SCOPE TRACE



NOTE:
BREAK LINK LOCATIONS
WERE AS SHOWN IN
SCHEMATIC, TABLE II

REPRESENTATIVE FUNCTIONAL TEST
SCOPE TRACE USING FOUR OF SIX
POSSIBLE BREAK LINK

APPENDIX C

TEST PROCEDURE 8867

TEST PROGRAM OUTLINE

FEASIBILITY DEMONSTRATION

of

BOOSTER CROSS-OVER SYSTEM

For 3 1/2 Inch SRB/MLP Frangible Nut

For

NASA
Marshall Space Flight Center

SOS Sales Order No. 1348 Customer Contract No. NAS 8-34651

Prime Contract No. _____

SOS Approvals	Date
Safety Tom Lucas	Date 8-6-83
Test Manager Wallace E. Campbell	7-14-83
Quality Assurance Clifford Reed	7-14-83
Project Engineer W. B. Heidemann	7/13/83
Program Director	
Director Engineering C. F. Darby	7/13/83

DOCUMENT STATUS

Submitted: Date _____

Approved: Yes ____ No ____ Date _____

Approval Document Location: _____

Approval Verification: _____

SOS-19113

Revision _____

TABLE OF CONTENTS

FIGURES

1.0 INTRODUCTION

Recent testing of the SRB/MLP Frangible Nut System (SOS Part Number 114850-9/Boosters P/N 114848-3) at NASA indicated a need to reduce the function time between boosters (2) within a single frangible nut. These boosters are initiated separately by electrical impulse(s). Coupling the output of each detonator with an explosive cross-over would reduce the function time between boosters (independent of electrical impluse) while providing additional redundancy to the system. SOS was awarded a contract (NAS8-34651) to conduct a "feasibility demonstration program" in an effort to demonstrate this effort, while maintaining compatability with the existing frangible nut.

2.0 DESIGN APPROCHES

2.1 Conceptual Design

Several design concepts were prepared by SOS. The individual designs were critiqued with trade off studies and presented to NASA for review (Ref. SOS Progress Report #1, dated 4/28/83).

A preliminary design review was conducted at SOS on May 25, 1983 (Ref. SOS Progress Report #2, dated 6/3/83). The design concept selected was that shown on SOS dwg. P117161, Sheet 1 (Figure 1).

2.2 Preliminary Design

Detail drawings representing individual frangible nut system components were prepared. These details reflect "full-up" characteristics of the selected design approach.

These components and their relationship to each other will be evaluated during this feasibility demonstration program.

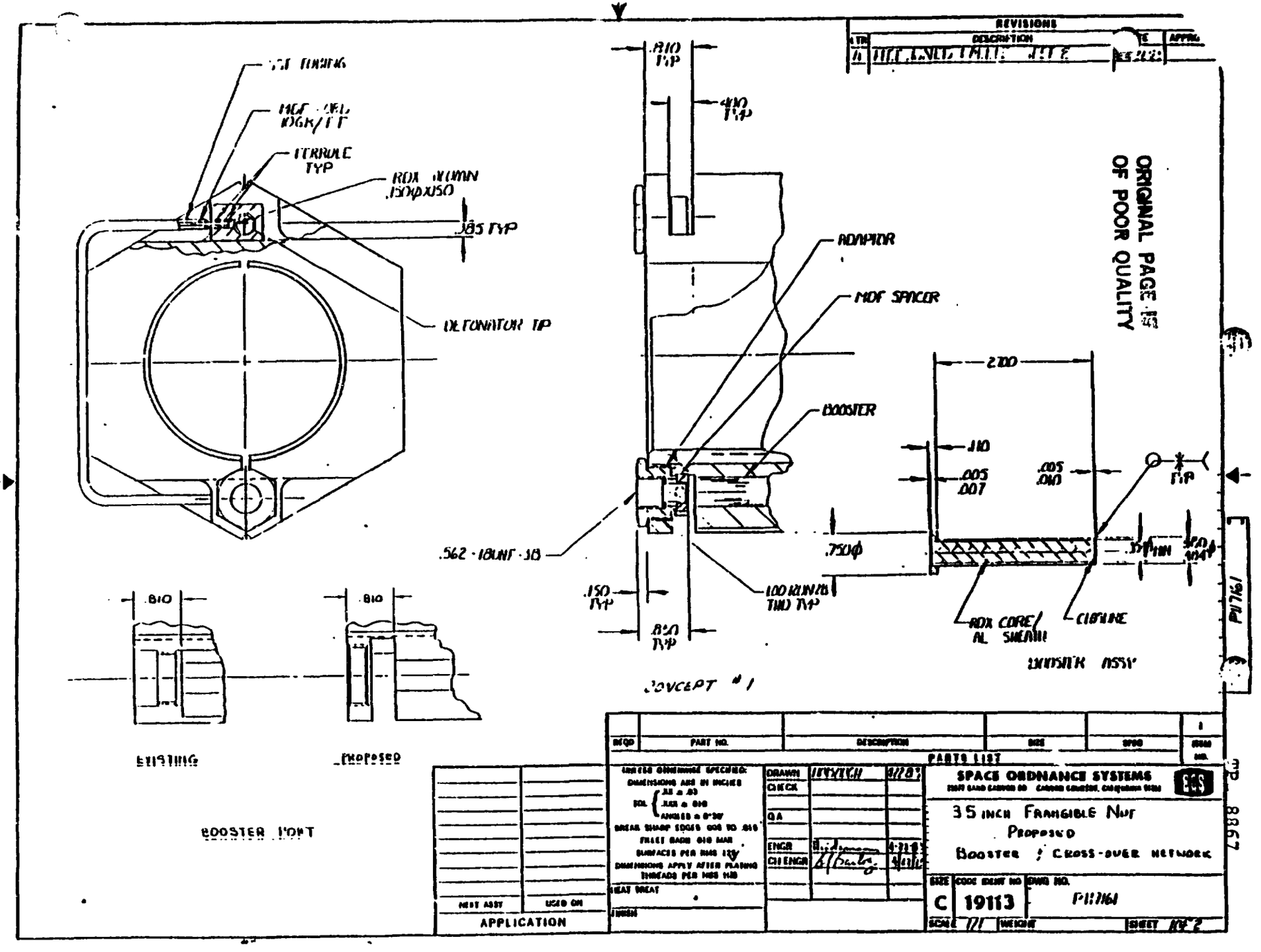

.810 TYP
.490 TYP
ADAPTOR
MDF SPACER
BOOSTER
DETONATOR TIP
.385 TYP
.562 - 18UNF - 3B
.150 TYP
.820 TYP
.100 MIN/B TYP
.750Ø
2.200
.810
.005 .007
.005 .010
TYP
.375 MIN
.490 .494
RDX CORE/ AL SHEATH
CLOSURE
BOOSTER ASSY
CONCEPT #1
.810
.810
EXISTING
PROPOSED
BOOSTER PORT
ORIGINAL PAGE IS OF POOR QUALITY
REVISIONS
DESCRIPTION
PARTS LIST
APPLICATION
SPACE ORDNANCE SYSTEMS
35 INCH FRANGIBLE NUT
PROPOSED
BOOSTER / CROSS-OVER NETWORK
SIZE
C
CODE IDENT NO
19113
DWG NO.
P11761
SCALE 1/1
WEIGHT
SHEET NO 2
8867

FIGURE 1

3.0 TESTING

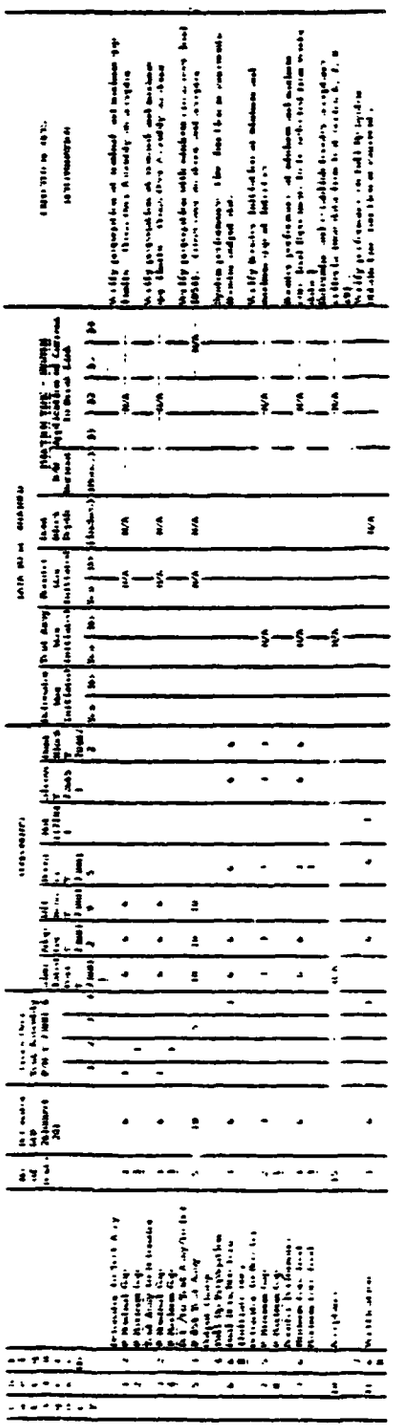
3.1 Test Outline

The testing to be accomplished is outlined in Table I, "Feasibility Demonstration Test Matrix" and identifies the following.

A. Test description
B. Test set-up/configuration
C. Number of tests
D. Components involved in the test
E. Data to be obtained
F. Expected results/determinations

3.2 Functional Tests

For test series 1, 2, 5, 6, 7, 8, 9 and 11 initiation will be by application of 3.5 amperes (10 msec. pulse) to the detonator SEB 26100094-201 (CFE) bridgewire. Series 3 & 4 will be the initiation of the cross-over assembly by a standard electric blasting cap. Series 10 does not require functioning (reduction of data from previous tests). Instrumented set-up for obtaining function time(s) is shown in Figure 8.



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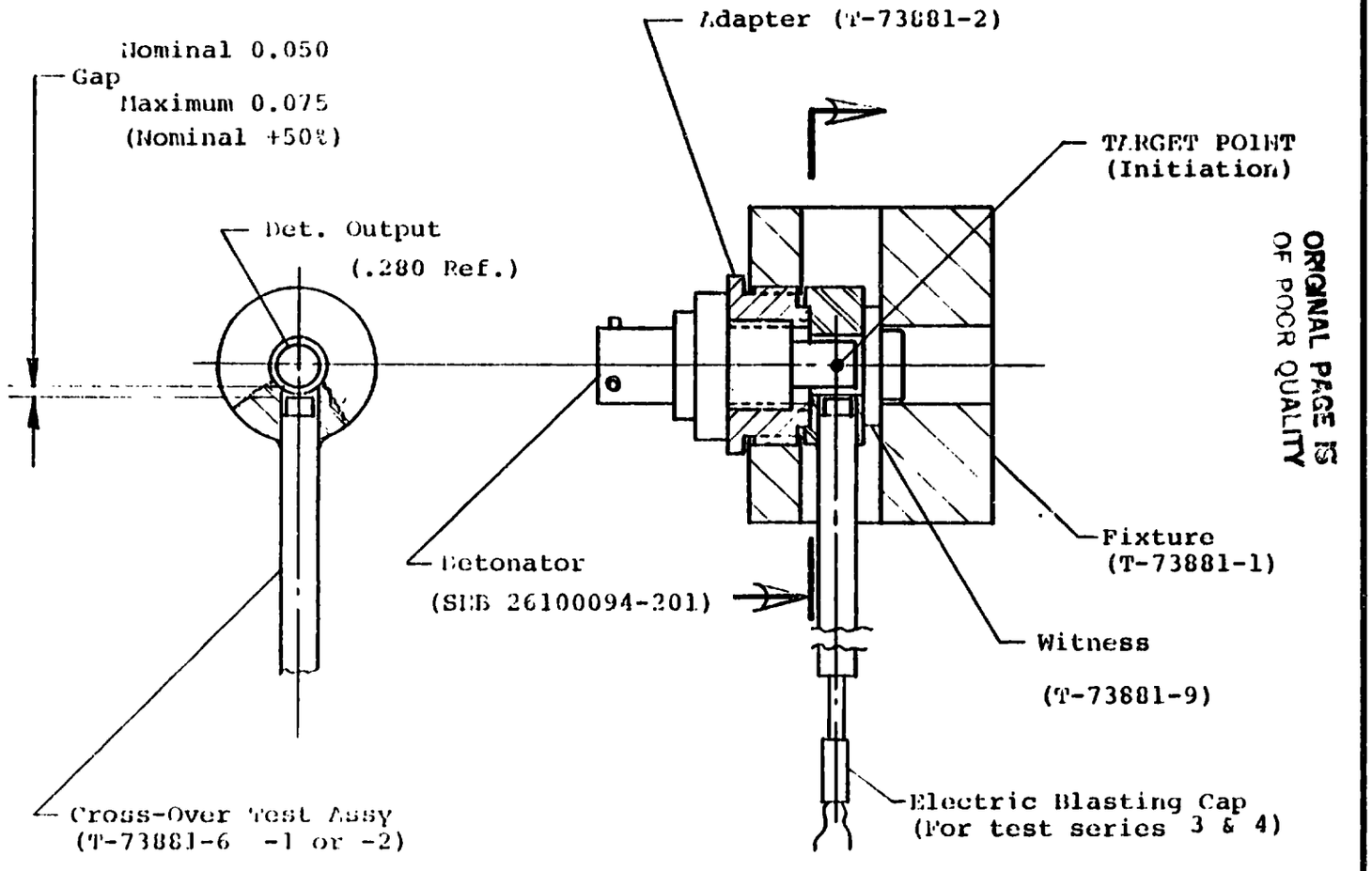

FIGURE 2

DETONATOR/CROSS-OVER TEST SET-UP

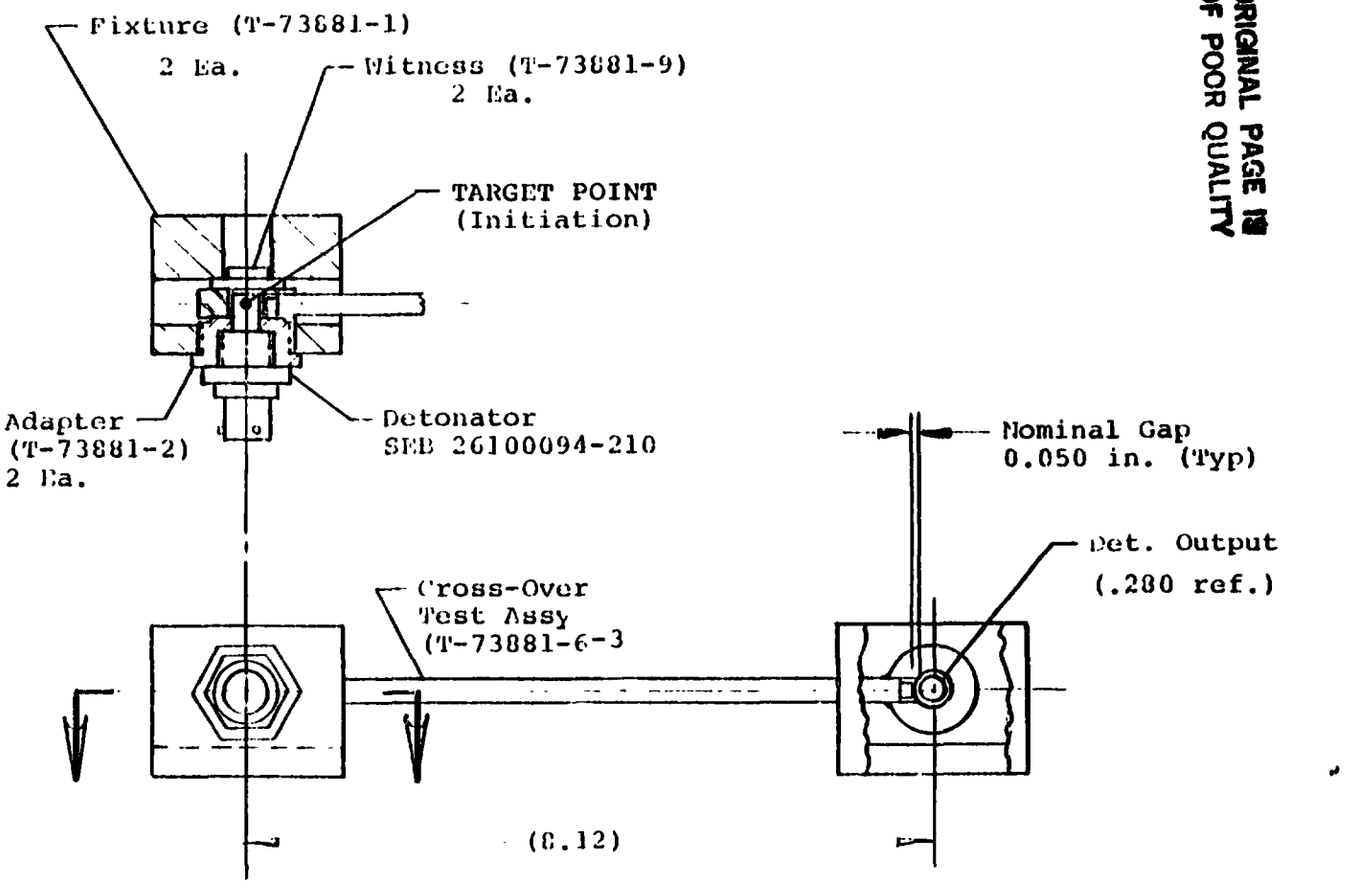

FIGURE 3
TEST SET-UP
DETONATOR/TO TEST ASSEMBLY/TO DETONATOR

(Note: Test Assembly T-73881-6-3 has 85% of nominal output charge)

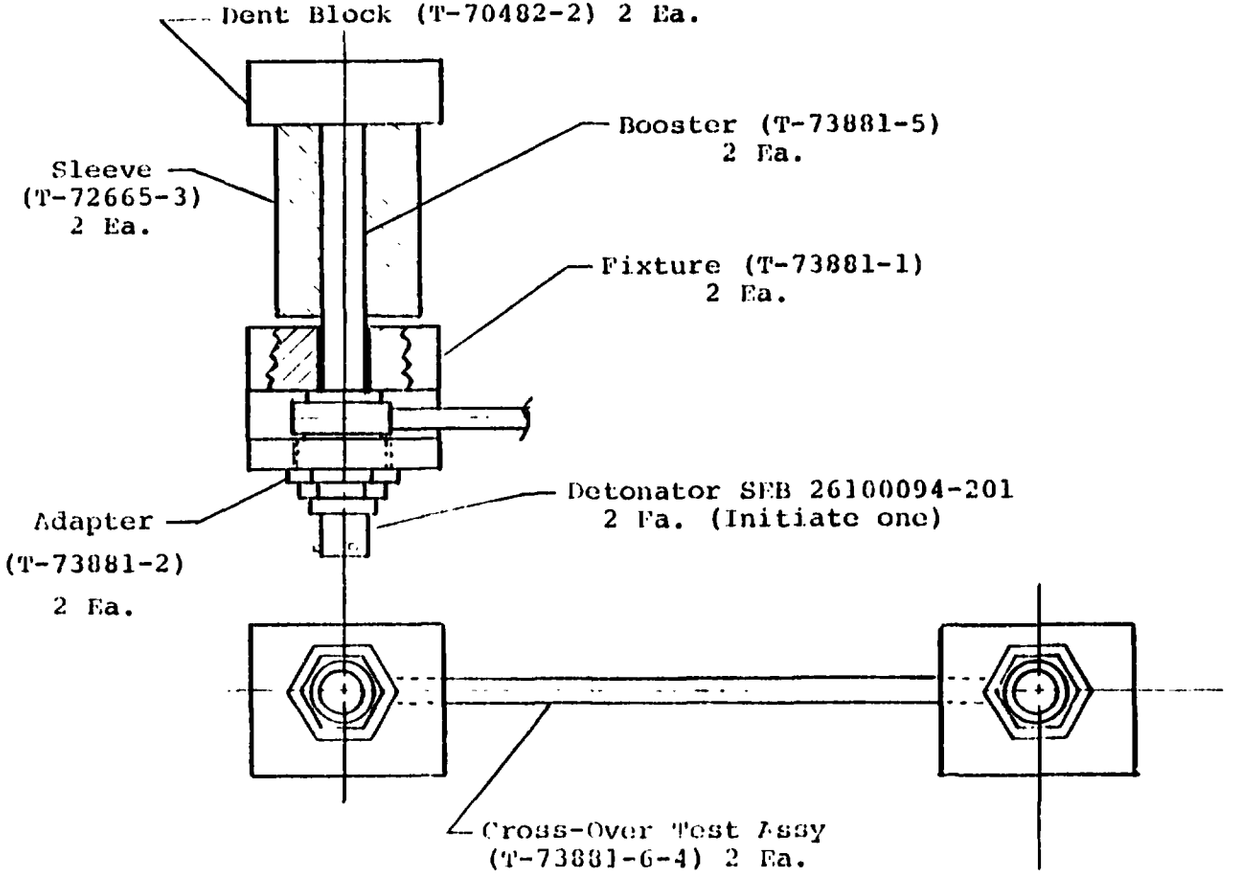

Figure 4

FULL SCALE PROPAGATION TEST SET-UP

(Dual Detonators & Boosters)

SPACE ORDNANCE SYSTEMS

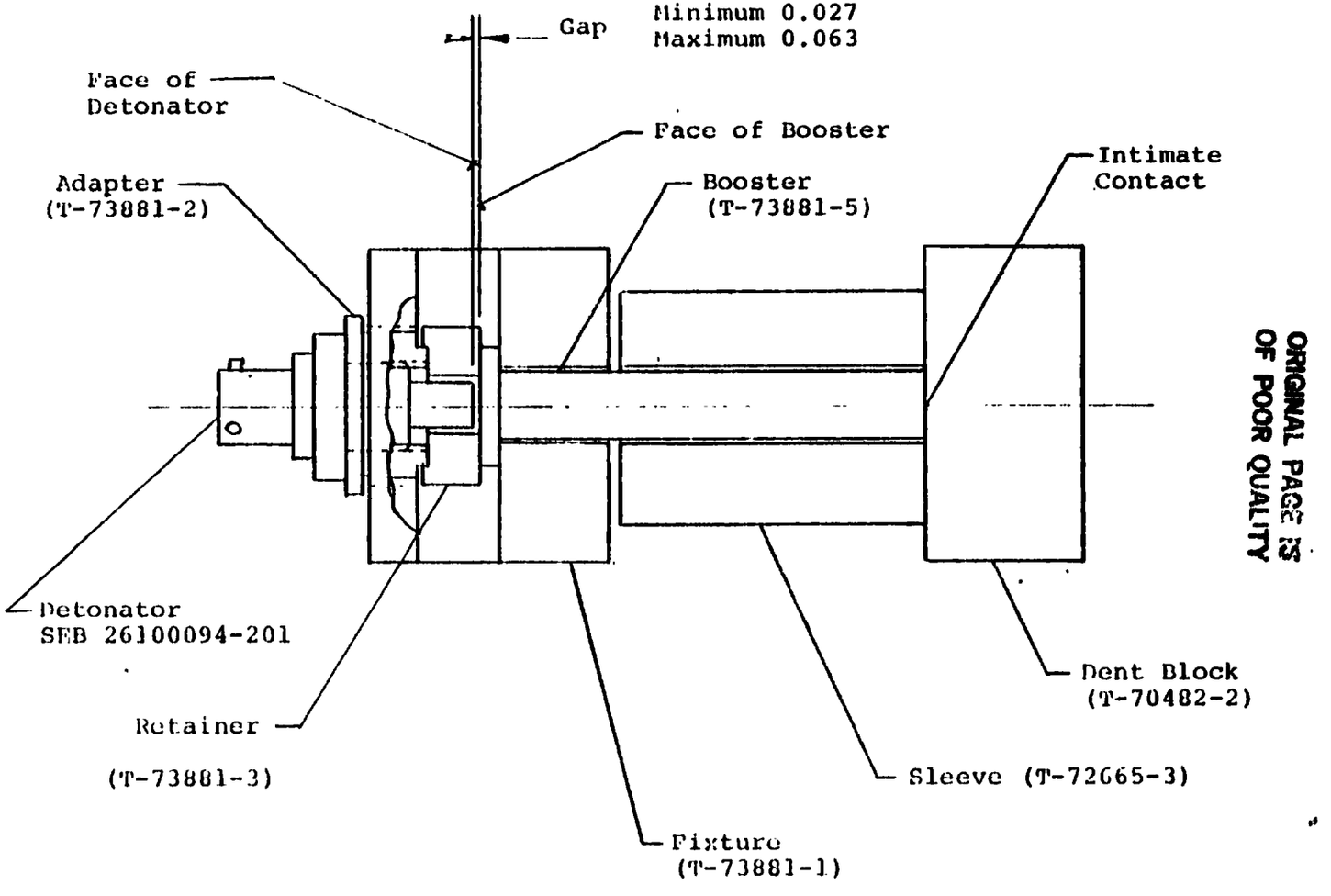

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FIGURE 5

DETONATOR TO BOOSTER TEST SET-UP

SOS

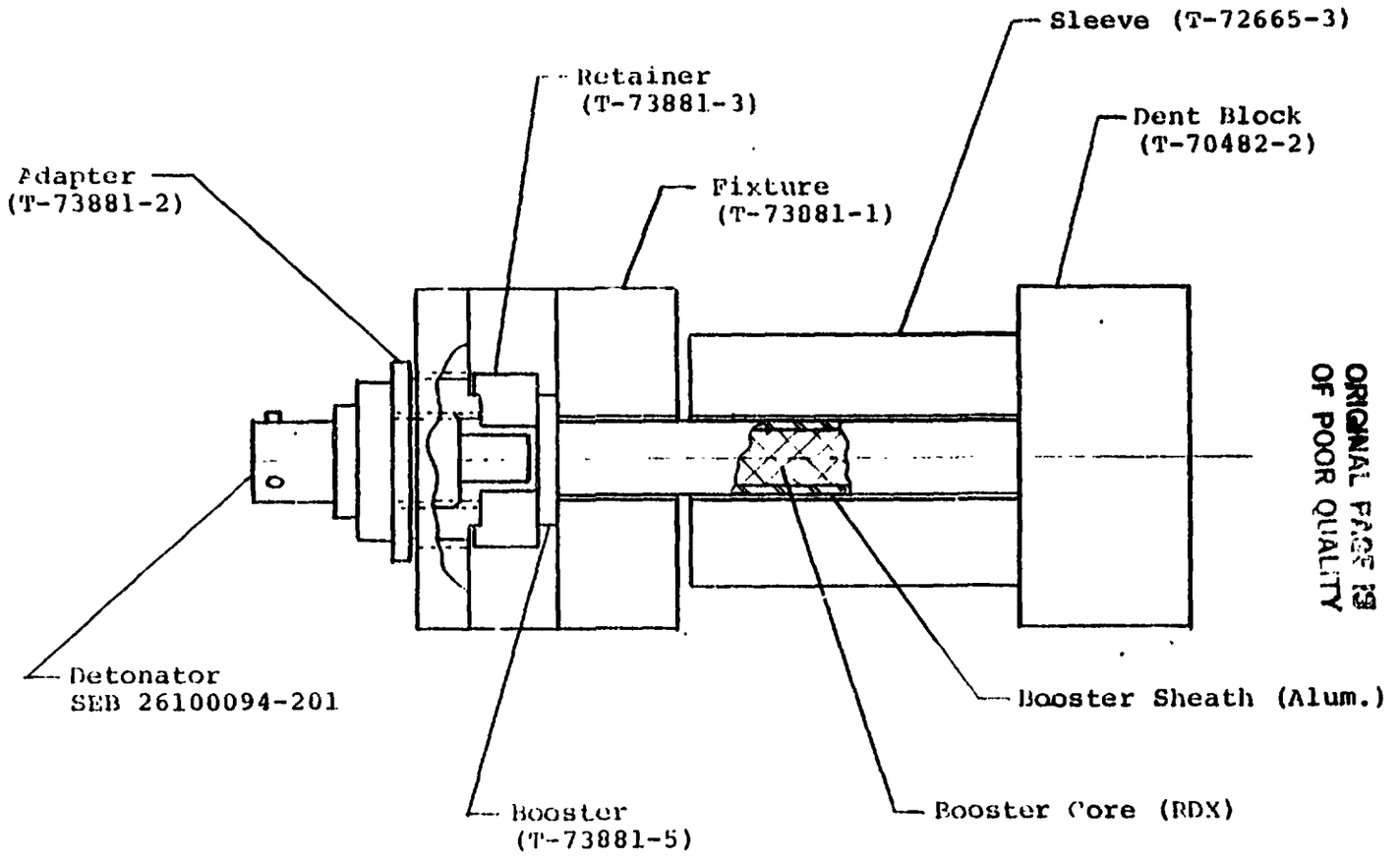

FIGURE 6

BOOSTER PERFORMANCE TEST SET-UP
(Evaluate Min. vs. Max. Load)

SOS

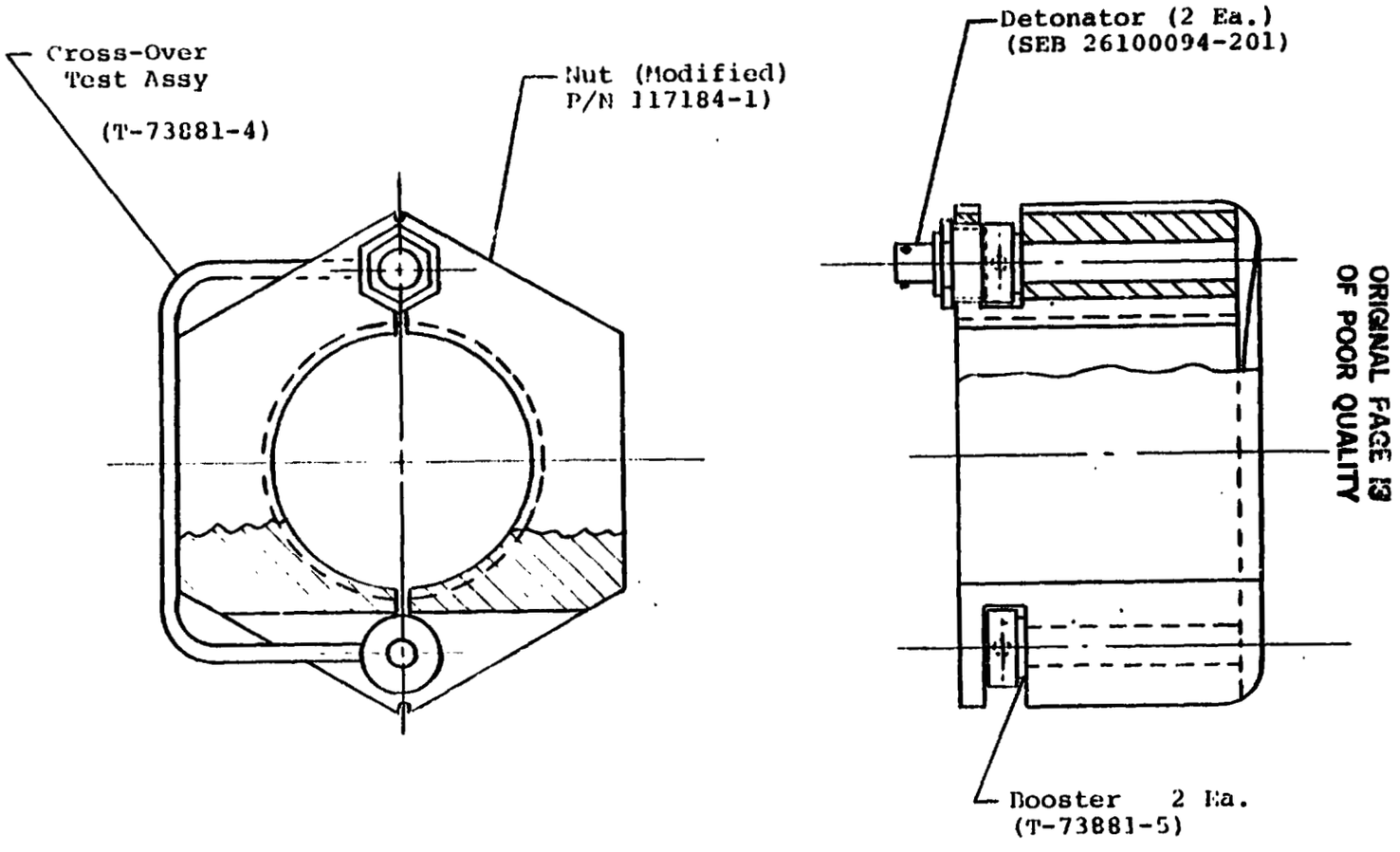

FIGURE 7

PERFORMANCE VERIFICATION TEST SET-UP

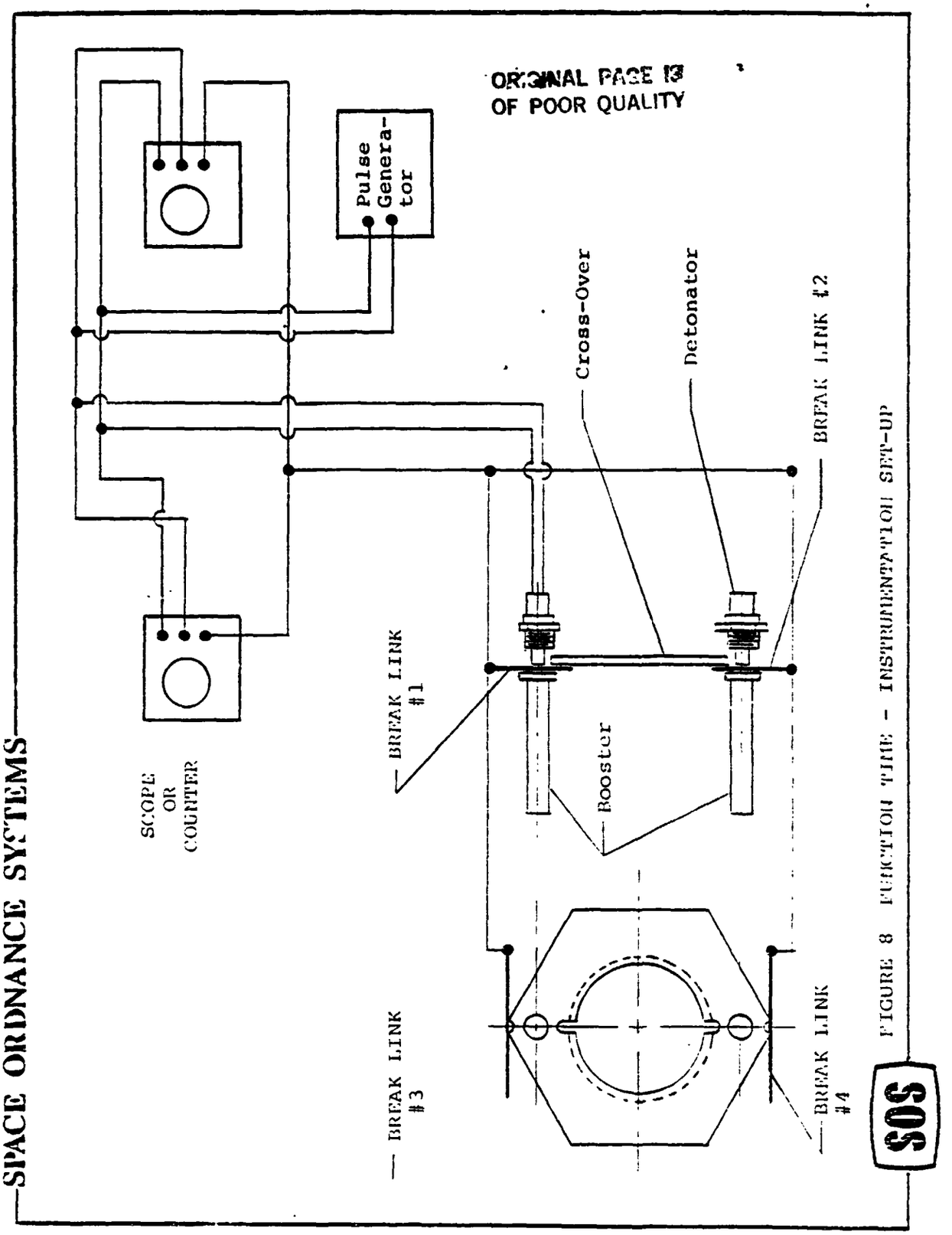

FIGURE 8 EJECTION TIME - INSTRUMENTATION SET-UP

4.0 DATA

Functional test data to be recorded shall be as required by test matrix Table I and data sheet No. 1, In addition the test equipment used will be listed on the equipment log sheet, data sheet No. 2

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TP 8867 DATA SHEET NO. 1

SOS JOB NO. 1348

TEST Series	TEST No.	TEST Figure	Detonator SEB 26100094 -201 S/N	"Gap" per Fig. (inch) Min. or Nom.	Max.	Detonator Initiated Yes	No	Cross-Over Initiated Yes	No	Booster Initiated Yes	no	Dent Block Depth (inch)	Time - Application of current to B/W Burn-out msec	Break Link #1	#2	#3	#4
1	1	2		.050	-----												
	2			.050	-----												
	3			.050	-----												
2	4			----	.075												
	5			----	.075												
	6			----	.075												
3	7			.050	-----												
	8			.050	-----												
	9			.050	-----												
4	10			----	.075												
	11			----	.075												
	12			----	.075												
5	13	3		NOM.													
	14																
	15																
	16																
	17																
6	18	4 & 8		.050	.063												
	19			.050	.063												
	20			.050	.063												
7	21	5		.027	-----												
	22			.027	-----												
8	23			----	.063												

STAMPS	TEST TECH (INITIAL)	APPROVAL SIGNATURES
	DATE	
	WITNESS (SOS)	
	WITNESS (CUSTOMER)	
	WITNESS (GOVT.)	

SPACE ORDNANCE SYSTEMS

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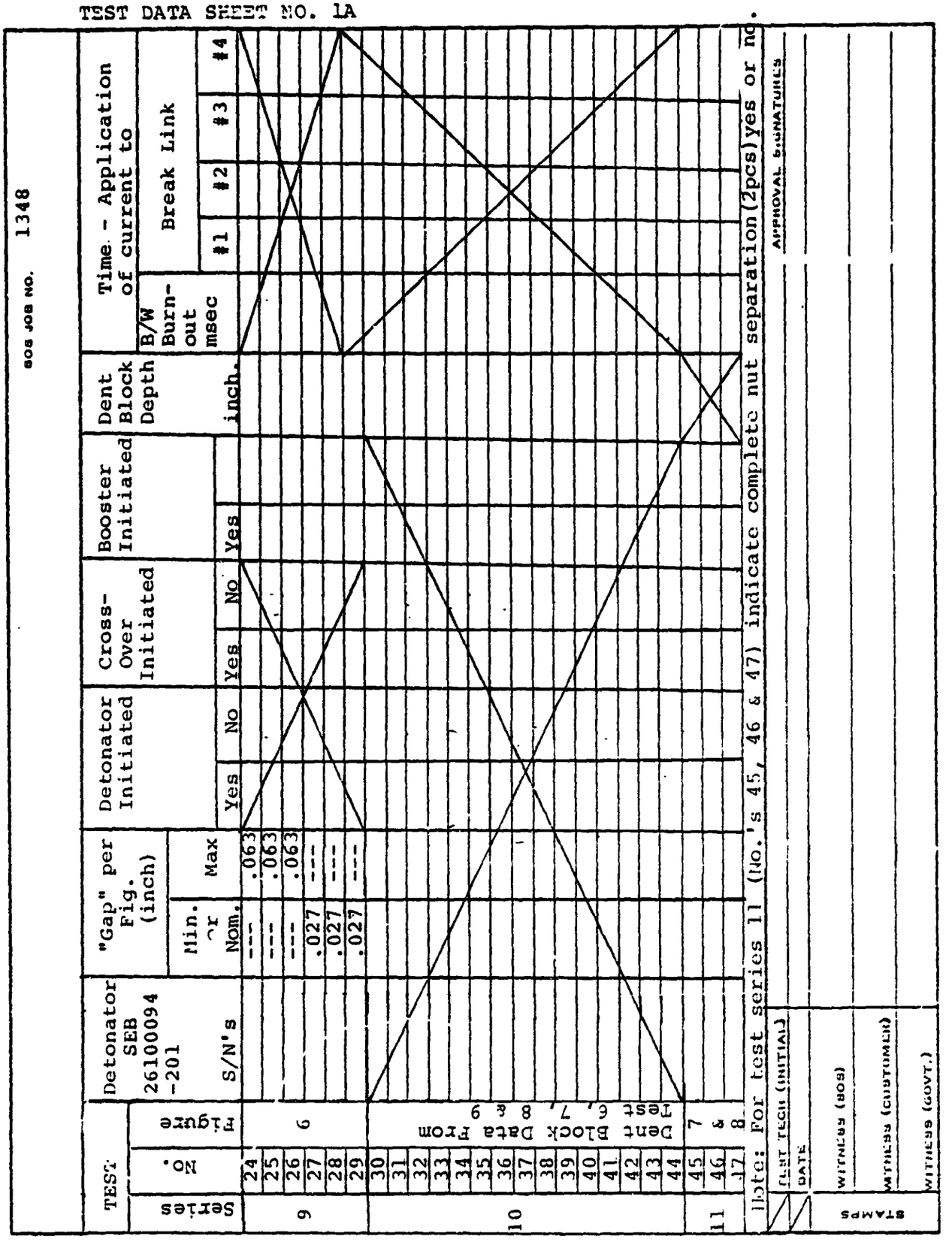
TP 8867

TEST DATA SHEET NO. 1A



PAGE 15

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EQUIPMENT LOG SHEET

SOS JOB NO.

			TEST EQUIPMENT LOG					
USED BY ✓	NAME OF EQUIPMENT	CALIB. I.D. NO.	MFGR.	MODEL NO.	SERIAL NO.	ACCURACY	CAL. DATE	CAL. DUE DATE

STAMPS

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TABLE I

FEASIBILITY DEMONSTRATION TEST MATRIX

Test No.	Description	No. of Units	Initiator SOS 26... -201	Cross-Over Test Assembly -1	-2	-3	-4	Standard T7001-1	Adapter T7001-2	T7001-9	Booster T7001-5	Nut 117184-1	Sleeve T72465-1	Lead Block T70402-2	Booster Was Initiated	Lead Block Depth (Inches)	Function Time (B/W Current; Application of Current to Bridge Link)	Objectives/Requirements
	Initiator to Test Assy																	
1	@ Nominal Gap	1	6	1	-	-	-	6	6	6		-	-	-	N/A	N/A	N/A	Verify propagation at nominal and maximum gap limits. Cross-Over Assembly as acceptor.
2	@ Maximum Gap	1		-	1	-	-											
	Test Assy to Initiator																	
3	@ Nominal Gap	1	6	1	-		-	6	6	6	-		-	-	N/A	N/A	N/A	Verify propagation at nominal and maximum gap limits. Cross-Over Assembly as donor.
4	@ Maximum Gap	1		-	1		-											
	Init./to Test Assy/to Init.																	
5	@ 85% Test Assy	5	10	-	-	5	-	10	10	10	-	-	-		N/A	N/A	N/A	Verify propagation with minimum explosive load (85%). Cross-over as donor and acceptor.
	Output Change																	
6	Full-Up Propagation; Lead Block/Booster (Functional)	1	6		-		1	6	6	-	6	-	6	6				System performance. Time function measurements Booster output data.
	Initiator to Booster																	
7	@ Minimum Gap	2	1		-			1	1	-	1	-	1	1			N/A	Verify Booster Initiation at minimum and maximum gap at interface.
8	@ Maximum Gap	[illegible]																
	Booster Performance																	
9	Minimum Core Load; Maximum Core Load	1	6					6	6		1		6	6			N/A	Booster performance at minimum and maximum core load (Specimens to be selected from weight data.)
10	Acceptance	15	-					N/A									N/A	Determine and establish booster acceptance criteria from data from test series 6, 7, 8 & 9).
11	Verification	1	6				1		6		6	1	-	-		N/A		Verify performance on Full-Up System. Obtain time function measurements.